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Mysore-2, India





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CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE
MYSORE-2, INDIA

January, 1963

PUBLISHED BY
CENTRAL FOOD TECHNOLOGICAL RESEARCH INSTITUTE
MYSORE-2, INDIA

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Introduction

The research activities of the Institute continued to make progress within the broad frame of the programme schedules approved by the scientific sub-committee.

A noteworthy development during the period under review is the recognition by International Organisations particularly, the Protein Advisory Group of the WHO/FAO/UNICEF, of the contributions made by the Institute in the field of protein-rich foods based on low-fat oilseed meals which are plentiful in this country. This recognition has led to the offer by the National Institute of Health, U.S.A. of the PL 480 funds for intensification of work on vegetable protein supplements in relation to protein malnutrition and development and utilization of newer formulations based on vegetable proteins. The work is being pursued vigorously in line with the plan outlined in the project.

The Utilization Research Division of the United States Department of Agriculture whose representatives have visited the Institute on a few occasions in the recent past have expressed interest in several lines of work. Proposals for further development of these investigations have been evaluated by the Utilization Research Division and are expected to be received from them along with requisite provision of funds under PL 480.

The U.S. Government Department of the Interior Bureau of Commercial Fisheries, Fish and Wild Life Service, have provided Rs 2.5 lakhs for investigations on the 'Influence of processing methods and other factors on the edible quality and nutritive value of fish flour'. The project will offer scope for expansion of facilities at the Mangalore Fisheries Station of the Institute and will be implemented in the course of the next year.

The lines of work proposed to be intensified under the N.I.H. Project relate to categories of infant foods, weaning foods and other protein foods, besides studies relating to the protein nutrition and to carbohydrate and fat metabolism.

A spray-dried formulation similar in composition and nutritive value to infant milk foods has been prepared from blends of coconut honey (20 parts), groundnut protein isolate (16 parts), skim milk powder (16 parts), hydrogenated vegetable fat (14 parts) and dextri-maltose (34 parts). Another formulation similar to skim milk powder has also been prepared by spray-drying a blend of coconut honey (30 parts), skim milk powder (25 parts), groundnut protein isolate (20 parts) and dextri-maltose (25 parts). Both the formulations have been fortified with vitamins and minerals. They have a protein ($N \times 6.25$) content of 26

per cent and 36 per cent respectively. The coconut honey 55-60 per cent total solids and 14-16 per cent protein ($N \times 6.25$) (on dry basis) used in these formulations is a product obtained by a modified Krauss-Maffei Process being investigated at the Institute.

Studies with albino rats have shown that the protein efficiency ratios during a 4 week feeding period of the infant food formulation (2.70) and skim milk powder formulation (2.64) compare favourably with that of skim milk powder (3.32) and are significantly higher than those of casein (2.44) and groundnut protein isolate (1.42).

Feeding trials on infants and weaned children with the infant food and skim milk formulations containing coconut honey will be undertaken.

A roller dried enriched wheat product having a protein content of 14-15 per cent and suitable for feeding of weaned children was prepared from blends of coconut honey and refined wheat flour (1:2 on dry solid basis). Animal experiments have shown that the above product possessed a protein efficiency ratio of 1.45 (during a 4 week feeding period as compared to 0.60 for wheat macaroni). Feeding trials will be undertaken to study the supplementary value of the enriched wheat product containing coconut honey to the diet of weaned children.

Roller-dried and spray-dried protein foods based on a 1:1 blend of full fat soya flour and groundnut flour and fortified with dl-methionine and suitable for supplementing the diet of weaned children were prepared. The process in short consisted of the following steps: (i) dispersion of the blend of soya flour and groundnut flour in 5-6 times the amount of water along with buffer salts, (ii) homogenisation, (iii) removal of coarse particles by passing through a vibrating sieve, (iv) steaming for 15 minutes, (v) roller or spray-drying, and (vi) fortification with dl-methionine, calcium salts and vitamins.

Animal experiments have shown that the roller-dried or spray-dried protein food possessed a protein efficiency ratio (2.52) comparing favourably with that (3.09) of skim milk powder. About 2,000 lb. of the spray-dried food was prepared at Udumulpet using a commercial type spray-drier and feeding trials on weaned children will be undertaken.

A protein food based on a 2:1:1 blend of groundnut flour, Bengalgram flour and fish flour from oil sardines, and adequately fortified with calcium salts and vitamins A and D, thiamine and riboflavin was prepared. Feeding trials on school children to assess the effect of a 40 g. daily supplement of the protein food on their growth and nutritional status are in progress.

A protein food based on a 1:1 blend of groundnut flour and soya flour fortified with dl-methionine, calcium salts and vitamins was prepared. Feeding trials on school children to assess the effect of a 40 g. daily supplement of the protein food on their growth and nutritional status are in progress.

Continuing the work on the refining of millets, the cereal group has worked out a technique for obtaining a white husk-free flour from

ragi. The whole grain is equilibrated with moisture as would just wet the skin, toughen and loosen it from the grain and the conditioned *ragi* is passed through a wheat mill. By appropriate modifications of the technique, *jowar*, wheat and *bajra* have been obtained without the skin.

The new method for the preparation of water-dispersible calcium caseinate based on the use of calcium hydroxide in sucrose and a reagent, has been covered by a patent and there are many enquiries from the trade for this process. The drum-dried preparation has acceptable organoleptic and storage qualities and has a PER of 2.2. Its value in the treatment of protein malnutrition has been established.

The hypoglycemic effects of protein in tolerance tests have been confirmed in over 70 per cent of the 24 diabetic subjects tested. Satisfactory arrangements have now been made at Ayurvedic and K.R. Hospitals, Mysore for suitable clinical material and detailed tests.

The unit on nutrition and cell function has continued its studies relating the biochemical events at the enzymatic and sub-cellular levels to various states of nutritional and metabolic stresses. Several interesting reports detailing the progress made have been published during the year.

By the growth of *A. aureus* on wheat and rice brans, two enzyme preparations (mouldy bran and precipitated enzyme powder) have been obtained. These products have proved their usefulness in enhancing the yield of juices and also in achieving simultaneously very good clarification. Mention may be made of the clear juices which have been extracted from pulps like banana, guava, mango and tomato, which indicates the scope that exists for their use in current industrial practice.

Microorganisms are being increasingly used for the fermentative production of amino acids such as lysine and glutamic acid. In a screening programme of about 1,000 bacterial cultures, a bacterial culture (No. 219) has been isolated which produces 4-5 mg./ml. of valine extracellularly; further screening and irradiation are being worked out to produce mutants which may yield lysine, an essential amino acid useful in food supplementation.

The presence of cellulosic fibre in protein rich oil cakes, often acts as a limiting factor for their better utilisation. An enzyme 'cellulase' capable of breaking down cellulose has been prepared from *Myrothecium varrucaria* and *Stachybotrys atra*. The enzyme preparation digests nearly 40 per cent of the original fibre in the coconut cake, thus facilitating the use of this protein rich material.

Kraft paper and hemp or other fibres have been used to produce a substitute for steel strap which could be employed to strap corrugated boxes and other packages. The results are encouraging and further work is in progress.

Work on the preparation of pectin and papain from raw papaya continued satisfactorily. The total yield of papain in 4 tappings is about

1 lb. for 10 plants. Tapped fruits have been utilised for the preparation of pectin. The recovery of pectin is 93-98 per cent in two extractions of 45 minutes each. Production of papain and pectin from the 5 acres papaya plantation taken on lease is underway. So far, 163 kilos of papain, 55 kilos of pectin and about 600 kilos of dry pulp containing 18-25 per cent pectin have been collected.

The effect of extraction of papain on the physical and chemical composition of papaya at various stages of maturity has been investigated. In general, lancing has no effect on the growth and quality of the fruit. In lanced fruits, however, the protein content was slightly less and the ascorbic acid content considerably more than in the control samples.

Following the encouraging results on the use of the banana pseudostem for the preparation of pulp and paper, methods are being standardised for an efficient and economic method of extracting the fibre. Of the various methods tried, Vasconocellos or Batex process (soda ash process) appears to be satisfactory. The yield of pulp is 43 per cent and paper made out of this pulp is quite strong and white in colour. This process does not involve costly equipment and is economical.

Investigations on the production and utilisation of groundnut protein isolate continued. The bulk of the air dried protein isolate from cake has been used along with milk powder for preparation of spray-dried infant food and protein food compositions containing 18 per cent proteins respectively.

Specifications for all the equipment required for setting up the plant for the integrated processing of groundnuts in collaboration with Tatas have been drawn up. The fabrication of a rotary vacuum filter and accessories including the protein extraction tank have been completed and the units are under trial for their performance.

The Krauss-Maffei coconut oil extraction plant was moved from Ernakulam and erected in the pilot plant laboratories. Preliminary trials with the re-designed worm supplied by the firm (compression rated 12:1 in contrast with 5:1 for the earlier work) have indicated possibilities for improved oil extraction in a single pass through the press. Trials with larger batches are under way.

Azeotropic and solvent extraction methods for processing of oil-bearing materials like coconuts and groundnuts, are also being developed.

Production of edible fish flour products with and without deodorization was undertaken by intensification of the work, during season, at Mangalore. The protein efficiency ratio of the fish flour (2.92) was nearly the same as that of skim milk powder (3.04). The proteins of fish flour supplemented to a marked extent those of groundnut flour and the PER of the protein blend was 2.56. Supplementation of poor Indian diets based on rice, wheat, *jowar* and *ragi* with fish flour at 3 per cent level brought about significant increases in the growth of rats comparable to those obtained by supplementation of a low quality maize-tapioca diet with

protein food of fish flour (so as to provide 10 per cent extra protein) made up the deficiencies in the diet and promoted good growth in albino rats comparable to that obtained by a supplement of skim milk powder. Feeding trials on school children to assess the supplementary value of the protein food to their diets is in progress.

Studies on the mode of action of the different types of acid activated clay samples showed that removal of lipoid from the insect cuticle is the chief factor responsible for insect mortality. This lipophilic property is independent of the moisture content of the acid-activated insecticidal clays. The feasibility of large-scale activation of clays for their use as insecticide is under examination.

The Regional Research Stations at Bombay, Nagpur, Lucknow and Trichur have started functioning and are now in new, spacious premises; the laboratories at Bombay and Lucknow have also been suitably equipped to take up quality control work under the Fruit Products Order. The Bombay Station has analysed over 200 samples including consignments intended for export. Various programmes of research are under way in all these Stations. Other Regional Research Stations will commence working shortly and Regional Advisory Committees will be set up for each Station.

The effect of pre-harvest spray of naphthalene acetic acid (NAA), 2: 4-dichlorophenoxy acetic acid (2:4-D) and maleic hydrazide (MH) on the post harvest physiology, storage and marketing of pineapples in Trichur. The application of 2: 4-D at 20 p.p.m., significantly reduces the circumference of the fruit as compared to control. NAA at 10 p.p.m. and 2:4-D at 200 p.p.m. also resulted in a decrease in circumference to some degree and elongation of the fruit. Decrease in circumference of the fruit will reduce cannery waste. Fruits treated with 100 p.p.m. alpha-NAA significantly increase the keeping quality.

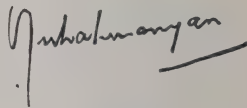
Further progress has been made on the work relating to fungicidal wax emulsions and on the use of growth regulators in quality control of horticultural produce. Facilities are being extended for studies on refrigerated and gas storage of fruits and vegetables.

A programme of operational research in a large pineapple canning factory in Trichur has been undertaken. The object of the work has been to find out aspects in the production system where intensive studies should lead to increased operational efficiencies and a decrease in the cost of production. The recommendations made by the team were implemented and plans are being formulated for carrying out similar studies in other factories. Industry has expressed considerable interest in such studies.

Arising from the recommendations of the F.A.O. Regional Seminar on Food Technology held at Mysore during August 1959, there have been some developments in regard to the setting up of a Regional Training Centre for Asia and the Far East as part of the activities of the Institute.

Member countries have expressed themselves in favour of such a centre being established in India and at Mysore and the F.A.O. has approached the Government of India in connection with this project indicating assistance from the Canadian Freedom from Hunger Committee. Government of India have given their approval in principle to the establishment of the Centre at this Institute.

Central Food Technological
Research Institute, Mysore

A handwritten signature in dark ink, appearing to read 'J. Subramanian', with a long horizontal stroke extending to the right.

Director

RESEARCH REPORTS

1. Storage and Preservation of Perishables

1.1 Skin coatings

1.1.1 Large-scale trials: The wax formulation was supplied to 127 different centres in the country for large-scale trials for extending the storage life and reducing spoilage during handling, transportation, storage and marketing of fresh fruits and vegetables. The reports so far received are very encouraging. Some commodities like betel leaves, ladies fingers, brinjals were tried by trade on their own and the reports state that the formulations supplied were equally effective. In betel leaves it has been reported to improve the taste also.

1.1.2 *Blood Red malta at Attari (Punjab):*

(In collaboration with Fruit Specialist, Punjab)

Sugarcane wax of 4 per cent strength containing 0.5 per cent sodium orthophenyl phenate (SOPP) was tried on a large-scale on *Blood Red malta*. Fruits selected were tree ripe and bright orange in colour. Observations on physiological losses in weight, general marketability and spoilage were recorded and it was found that, on 10 per cent spoilage basis, treated fruits could be kept for about 30 days as against 10-12 days in the case of untreated fruits.

1.1.3 Apples at Kulu and Simla: Wax emulsion was supplied in large quantity to be tried on different varieties of apples, viz., *Golden Delicious*, *Red Delicious*, *Granny Smith*, *Rome Beauty* and *Jonathan*. It has been observed that about 20-25 per cent of spoilage of fruits could be saved by skin coating.

1.1.4 Mandarin oranges at Nagpur: Loose skin oranges were treated with 4 per cent sugarcane wax emulsion containing 0.5 per cent SOPP at Regional Research Station of the Institute. The spoilage of treated oranges was reduced while storage life and marketability were enhanced.

1.1.5 *Tomatoes at Bombay:*

(In collaboration with Regional Research Stations Division)

Large-scale waxing of *Jambu* tomatoes where green and ripe tomatoes were separately treated, was conducted with 4 per cent wax emulsion containing 500 p.p.m. of maleic hydrazide. The effect of the waxing was compared with the untreated tomatoes. Data on the ripening changes, intensity of the colour, spoilage and marketability were collected. The fruits in these experiments were filled in baskets in the usual manner as they are stored in the factories at room temperature. On the 3rd day of the storage, the spoilage in the untreated green tomatoes went up to the

extent of 17.33 per cent as against 5 per cent in the case of the treated tomatoes. In ripe tomatoes, the spoilage at the end of the 3rd day was as high as 15.4 to 39.3 per cent in control as against 2.6 to 8.9 per cent in treated lots. In general, it has been reported that waxed fruits were much better in appearance than the ones kept as control in all the batches. In the control, heavy fungus growth was observed on the 2nd day. The treated fruits could be kept easily for 5 to 6 days with about 10 per cent spoilage. Ketchup prepared separately from the waxed and unwaxed fruits showed, on examination, that the one prepared from the treated batch was superior to the other prepared from the untreated batch with reference to intensity of the colour.

1.1.6 Banana at Bardoli: Large-scale trials on banana with 4 per cent sugarcane wax emulsion were conducted on $\frac{3}{4}$ full, unripe bananas and showed that such treated bananas ripened uniformly and the development of yellow colour was intensive. Their marketability was enhanced and spoilage reduced.

1.1.7 Mangoes at Lucknow: Large-scale trials on *Langra* and *Dasehri* mangoes conducted at Lucknow showed that mangoes treated with 4 per cent fungicidal wax emulsion had greater retention of moisture, delay in ripening and lesser spoilage with extended storage life. The shrivelling in the case of *Dasehri* mangoes was much less in waxed fruits as compared to the control or fruits ripened in straw.

1.1.8 Litchies at Muzzaffurpur (Bihar) and Lucknow: Application of the 4 per cent wax emulsion with 0.5 per cent flit 406 fungicide, extended the storage life of the fruit by 40-50 per cent at room temperature and retained the freshness of the fruit.

1.2 Design and fabrication of wax emulsion making unit

(In collaborations with Engineering Division)

The wax emulsion making unit of a batch type has a production capacity of five gallons of concentrated emulsion in 2 hours. It consists of two tanks, one for boiling soft water and the other, a double jacketed tank for making the wax emulsion. The stirrer is operated by gear motor which can maintain a speed range of 20-100 r.p.m. The approximate cost of the unit will be about Rs 850 which might be less, if manufactured in large numbers.

The preparation of various composition of sugarcane wax emulsion had been standardized. One pound of sugarcane wax can make 2.2 gallons of 4 per cent wax emulsion which in turn can treat the following quantities of different commodities.

Oranges	2 tons	Tomatoes	1.2 tons
Sathgudi oranges	2.5-3 „	Potatoes	2.5 „
Mangoes	5 „	Banana	1 „
Limes	1 „	Guava	2 „
(6% to be used)		Apples	2 „

1.3 Wax application unit

(In collaboration with Engineering Division)

The hand operated unit (village model) consists of a tank with movable perforated carrier which, after loading, is immersed in the wax emulsion. After treatment, the perforated carrier goes up in an inclined position by moving the handle, and the treated fruits roll out on a gravity conveyer. At the end of the conveyer, the fruits are kept in rows for drying as usual before packing. The unit can treat large number of fruits in a short time, and can be operated even in remote villages where electricity is not available. The whole unit is portable and approximate cost will be about Rs 250 with the possibility of the cost going down considerably, if manufactured in large numbers.

1.4 Effect of application of wax emulsion on the storage behaviour of guavas

Fully mature, hard and green fruits were harvested from the Institute orchard and treated with 8 per cent and 12 per cent sugarcane wax emulsion containing 0.5 per cent sodium orthophenyl phenate SOPP. A set of untreated fruits were kept as control. The physical and chemical changes *e.g.*, physiological loss in weight, respiration, changes in acidity, ascorbic acid, reducing and non-reducing sugar, colour development and wastage were followed at regular intervals during storage at room temperature. There was an increase of 50 per cent of storage life in fruits treated with 12 per cent wax emulsion.

1.5 Effect of pre-harvest spray of wax emulsion on pineapple

Field trials of pre-harvest spray of 4 per cent sugarcane wax emulsion with or without, 2, 3, 5, 6-tetrachloronitrobenzene (TCNB) on pineapple fruit, were carried out, in a randomised block design, fifteen days before harvest at Regional Research Station, Trichur. After harvest, the treated and untreated fruits were stored at room temperature at Trichur (90-98°F). Based on organoleptic evaluation, the average keeping quality of the fruits was 6 days in control, 14 days in fruits sprayed with wax emulsion and 15 days in fruits sprayed with wax emulsion containing 300 p.p.m. of TCNB (tetrachloronitrobenzene). The spoilage was 28.5 per cent in control as against nil in treated fruits after a storage of 5 days. After 10 days, here was 94.3 per cent spoilage in control as against only 8.5 per cent in wax treated and 5.7 per cent in wax+TCNB treated fruits. Large-scale application of pre-harvest spray of wax emulsion is in progress at Trichur.

1.6 Growth regulators

1.6.1 Onions: Pre-harvest spray of maleic hydrazide (MH) was carried out on one acre of onions at Sevagram, Wardha. It has been

found that the treated onions did not sprout during the rainy season while being stored at room temperature.

1.6.2 Pineapples:

(In collaboration with Regional Research Stations Division)

Large-scale trials were conducted with a view to studying the effect of pre-harvest spray of naphthalene acetic acid, 2: 4-dichlorophenoxy acetic acid (2: 4-D) and MH on the post-harvest physiology, storage and marketing of pineapples. 25 days prior to harvesting, different concentrations of the above plant growth regulators were sprayed. Application of 2: 4-D at 20 p.p.m. significantly reduced the circumference of the fruit as compared to control. Alpha-naphthalene acetic acid (alpha-NAA) at 10 p.p.m. and 2: 4-D at 200 p.p.m. also registered a decrease in circumference to some degree and increase in the length of the fruit. Decrease in circumference of the fruit is of commercial importance as the cylindrical fruit will reduce the cannery waste. Fruits treated with 100 p.p.m. of alpha-NAA significantly increased the keeping quality.

1.6.3 Mangoes: Large-scale pre-harvest (one month before harvest) application of growth regulators was conducted in a nearby orchard on selected healthy mango trees. The following growth regulators and concentrations were used: (1) control, (2) 2:4:5-trichlorophenoxy acetic acid (2: 4: 5-T) 25 p.p.m., (3) 2: 4: 5-T—75 p.p.m., (4) alpha-NAA—25 p.p.m., (5) alpha-NAA—75 p.p.m., (6) MH—250 p.p.m., (7) MH—750 p.p.m. They were then harvested and stored at room temperature for further storage studies. The data showed that growth regulators like 2: 4: 5-T, alpha-NAA and MH in low concentrations increase the weight of the fruits. The chemical changes in regard to acidity, ascorbic acid, T.S.S. and physiological losses in weight (PLW) were followed at regular intervals. It was observed that vitamin C retention was better in all the treated fruits. No difference was found in the physiological losses in weight in treated and untreated fruits. The pre-harvest spray of mangoes with various growth regulators have increased the storage life by retarding ripening process as evidenced by treatments with 2: 4: 5-T at 75 p.p.m. and MH at 750 p.p.m. However, treatment with 2: 4: 5-T at 25 p.p.m. hastened ripening. Further work is in progress on the mode of action of various concentrations of these growth regulators in influencing the ripening process.

1.6.4 Oranges (Coorg):

(In collaboration with Horticulturist, I.C.A.R. Scheme, Gonicoppal)

Pre-harvest (one month before harvest) application of growth regulators on oranges on selected trees was conducted on a large scale.

The following growth regulators and concentrations were used: (1) control, (2) 2: 4-D, 100 p.p.m., (3) 2: 4-D—20 p.p.m., (4) 2: 4: 5-T—

100 p.p.m., (5) 2: 4: 5-T—20 p.p.m., (6) alpha-NAA—100 p.p.m., and (7) alpha-NAA—10 p.p.m. Observations were made at regular intervals regarding the maturity of fruits on the tree. When ready for harvest, the fruits were harvested separately in respect of various treatments and brought to the laboratory without any delay. Weights of the fruits, pomace, skin and seeds were determined. PLW and shrivelling, wastage and marketability were recorded at regular intervals.

The oranges sprayed with 2: 4-D at 20 p.p.m. had 40 per cent fruits of marketable quality at the end of 22 days of storage, as against none in unsprayed fruits. 2: 4: 5-T in higher concentration had deleterious effect on fruits, as they dried up faster during storage at room temperature. There was no significant difference in PLW among treated and untreated fruits.

Coorg oranges sprayed with alpha-NAA (10 p.p.m.) had 12 per cent more weight than the control for the same number of fruits. 2: 4: 5-T in low concentration had also increased the weight in oranges. 2: 4-D when used in high concentration, yielded fruits smaller in size. In conclusion, growth regulators in low concentrations help in increasing the weight of the fruits from 6 to 12 per cent.

1.6.5 Effect of 2: 3: 5: 6-TCNB on growth characteristics of *Thielaviopsis paradoxa* and *Penicillium italicum*: The growth of *Thielaviopsis paradoxa* and *Penicillium italicum* on potato-dextrose-agar medium was completely inhibited by TCNB for over 10 days after inoculation of the fungi at 1300, 650, 300 and 150 p.p.m. It was observed that there was slight growth of *Thielaviopsis* at 150 p.p.m. level after 15 days and little activity at 300 p.p.m. level after 20 days. *Penicillium* produced very slight growth 20 days after inoculation at 150 p.p.m. TCNB in wax emulsion has been suggested as a pre-harvest spray and post-harvest dip for pineapples to control black rot during storage, transportation and marketing. Extensive field trials are in progress at Trichur to study and to recommend optimum concentrations.

1.7 Combination of skin coating and growth regulator

1.7.1 Effect of application of wax emulsion on the storage behaviour of mangoes sprayed with growth regulators one month before harvest: Mangoes sprayed with plant growth regulators one month before harvest were brought to the laboratory for waxing and conducting further storage studies at room temperature. The pre-harvest spray treatments were as follows: (1) control, (2) 2: 4: 5-T—25 p.p.m., (3) 2: 4: 5-T—75 p.p.m., (4) alpha-NAA—25 p.p.m., (5) alpha-NAA—75 p.p.m., (6) MH-40—250 p.p.m. and (7) MH-40—750 p.p.m. All these fruits in each treatment were coated with 6 per cent wax emulsion containing 0.4 per cent flit 406, and stored at room temperature. The control (i) was subdivided into two lots; one lot was waxed and the other was kept unwaxed. The following observations were made at periodical intervals: (a) physiological

losses in weight, (b) percentage ripening, green and wastage in fruit and (c) chemical changes with reference to vitamin C, total soluble solids and acidity.

It was observed that there was considerable delay in ripening in all the treated fruits as compared to control. The PLW was much less in the waxed fruits as compared to unwaxed, but there was no significant difference among fruits treated with various growth regulators. Vitamin C retention was better in all the treated fruits as compared to control. In the case of fruits previously treated with 750 p.p.m. of MH as a pre-harvest spray, the storage life was increased by 75 per cent based on 50 per cent ripening.

1.7.2 *Effect of application of wax emulsion on the storage behaviour of Coorg oranges sprayed with growth regulators one month before harvest:* The Coorg oranges which were sprayed with various growth regulators one month before harvest were brought to the laboratory and then coated with wax emulsion containing 4 per cent solids and 0.4 per cent flit 406. The treatments were: (1) control without wax emulsion, (2) control with wax emulsion, (3) 2: 4-D—100 p.p.m. + wax emulsion, (4) 2: 4-D—20 p.p.m. + wax emulsion, (5) 2: 4: 5-T—100 p.p.m. + wax emulsion, (6) 2: 4: 5-T—200 p.p.m. + wax emulsion, (7) alpha-NAA—100 p.p.m. + wax emulsion and (8) alpha-NAA—10 p.p.m. + wax emulsion.

The observations were made at regular intervals with reference to PLW, percentage wastage, shrivelling, marketability and chemical changes during storage at room temperature. The Coorg oranges, sprayed with alpha-NAA—10 p.p.m. and 2: 4: 5-T—200 p.p.m. in the field one month before harvest when coated with wax emulsion, before storage, had 92 per cent of marketable fruits at the end of a storage period of 22 days. The control without wax coating had 72 per cent marketable fruits after 15 days of storage. The fruits treated with wax emulsion in all the treatments were better in flavour, taste and appearance as compared to control.

1.7.3 *Effect of wax-growth regulator on the storage and processing of tomatoes:* Mature green tomatoes, freshly harvested from the field, were treated with 4.8 per cent fungicidal wax emulsion with and without growth regulators. MH; 500 and 2,000 p.p.m., 2: 4-D; 2 and 20 p.p.m. and alpha-NAA; 25 and 250 p.p.m. were used in the wax emulsion. The treated and untreated tomatoes were stored at room temperature (75-92°F; R.H. 47-70 per cent) and at optimum low temperature (47-50°F; R.H. 85-90 per cent). During storage periodical observations were made with reference to PLW, ripening, colour development, wastage, respiration, acidity, pH, ascorbic acid, reducing and non-reducing sugars, moisture, ash and total soluble solids. Ketchup was prepared from differently treated tomatoes and its physical and chemical changes during storage at room temperature and at 47-50°F were studied. It has been found that treatment of tomatoes with wax-growth regulator extends the storage

life by 50 per cent at room temperature and intensity of colour development of fruits in assorted varieties was remarkable. Ketchup prepared from treated fruits possessed a much better colour than that prepared from the control and there was a better retention of the colour of the product during storage.

1.7.4 Effect of wax-growth regulator on the storage behaviour of limes and tomatoes stored at room temperature: Freshly harvested green limes were brought to the laboratory from the market and the following treatments were given: (1) coated with wax emulsion (12 per cent solids + 0.4 per cent, flit 406) 1,000 p.p.m. of indolepropionic acid (IPA), (2) wax emulsion + 2,000 p.p.m. of IPA, (3) wax emulsion + 1,000 p.p.m. of indolebutyric acid (IBA) (4) wax emulsion + 2,000 p.p.m. of IBA, (5) coated with only wax emulsion and (6) control.

Periodical observations were made in regard to PLW, wastage and marketability of limes and tomatoes. Limes treated with wax emulsion containing 2,000 p.p.m. IBA and 1,000 p.p.m. of IPA had the least physiological loss in weight as compared to control.

The limes coated with wax emulsion containing IBA at 2,000 p.p.m. had 75 per cent marketable fruits at the end of 17 days of storage whereas the control had none of marketable quality. Growth regulators in wax emulsion, when applied to limes, delay colour changes and prevent moisture loss.

Freshly harvested tomatoes were obtained from fields and treated accordingly: (1) control, (2) wax emulsion, (3) wax emulsion containing 300 p.p.m. dinitrophenol (DNP), (4) wax emulsion containing 1,000 p.p.m. of DNP, (5) wax emulsion containing 300 p.p.m. of IPA, (6) wax emulsion containing 1,000 p.p.m. of IPA, (7) wax emulsion containing IBA at 300 p.p.m., and (8) wax emulsion containing IBA at 1,000 p.p.m. After 12 days of storage at room temperature, the number of fruits which maintained green colour was the highest in the fruits treated with wax emulsion containing 1,000 p.p.m. IBA (8) followed by treatments (3), (4), (5), (6), (2) and (1). Treatment (8) delayed colour changes considerably. Further work is in progress.

1.8 Storage under modified atmosphere

1.8.1 Gas storage of potatoes: The gas storage of 5 months old potatoes was carried out at three different temperatures, viz., room temperature, 52-55°F and 35-38°F under three modified atmospheres viz., 5, 10 and 15 per cent carbondioxide. The influence of growth regulator (methyl ester of alphanaphthalene acetic acid) in wax emulsion was also compared with gas storage. Important physical and chemical changes, like physiological loss in weight, wastage, sprouting, respiration, moisture content, acidity, ascorbic acid, reducing and non-reducing sugars and starch were estimated at regular intervals.

It has been found that 10 per cent CO₂ at 52-55°F, inhibits sprouting in potatoes completely, while 5 per cent of CO₂ at the same temperature

accelerates sprouting. 15 per cent CO₂ inhibits sprouting, but symptoms of black-heart develop during long storage. Potatoes, when removed from 5 per cent CO₂ atmosphere, germinated satisfactorily. Stored potatoes also gave excellent products, like french fries, chips and powder. It may be possible to store potatoes at 52-55°F under 10 per cent CO₂ atmosphere and potatoes thus stored can also be transported to long distances. Work in this direction is in progress.

1.9 Refrigerated storage

1.9.1 Tomatoes: Tomatoes of two varieties were harvested from the Institute field and their cold storage and ripening behaviour were studied on a large scale. Three temperatures of storage were selected and various observations including consumers' acceptability recorded at regular intervals. It has been found that fully ripe red fruits could be stored at 32-35°F for 10 days with less than 5 per cent wastage, while green fruits could be stored at 39-42°F for 20 days. The green fruits after storage could be satisfactorily ripened in about 3 days time at 68-70°F and then further stored for about 3 days at 32-35°F. Further work is in progress.

1.9.2 Limes: Acid limes, at yellow and green stages, were obtained from the market to determine the optimum cold storage conditions and the approximate storage life. Five temperatures of storage were selected and changes in acidity, vitamin C, reducing and non-reducing sugars, moisture etc., were recorded for the peel and the juice of the fruits stored at different temperatures. It has been found that yellow ripe acid limes could be stored at 52-55°F, 85-90 per cent R.H. for two months in an acceptable condition. Below this storage temperature, most of the limes suffered from physiological diseases, i.e., browning, discolouration of surface and microbial infection. At higher temperature above 52-55°F, fruits became discoloured and shrivelled rapidly. Use of fungicides, like flit 406 (Captan 50 per cent), did not help in controlling the disease due to infection during storage. The common diseases which have been observed during storage are stem end rot due to *Phoma* and soft rot due to *Oospora citri*.

Green limes, which were stored under the same conditions, behaved in similar way. But after 4 weeks of storage, fruits turned completely yellow and minimum wastage was observed at 52-55°F storage temperature. Further work in this line is still in progress to control the storage diseases of acid limes due to microbial infection.

1.9.3 Jamun (*Eugenia jambulana*): Jamun fruits were obtained from the market and stored at six storage temperatures to determine the optimum storage conditions and the approximate storage life. Fruits were also packed in polyethylene bags of 250 gauge with and without ventilation and stored in different storage temperatures. Biochemical changes like vitamin C, sugars, acids etc., were recorded at regular intervals

at all the storage temperatures. Fruits could be stored only for 6 days at room temperature and for 12 days at 67-70°F. Most of the fruits came down with microbial infection due to fungi. Fruits stored in polyethylene bags without ventilation were better than the control at all storage temperatures. Since fruits were fully ripe, ventilation in polyethylene bags did not show any significant effect. Fruits stored at lower temperatures were found to be better than those stored at 67-70°F and above. Further work is in progress.

1.9.4 *Sapota*: Mature fruits were harvested from the Institute orchard and stored at different storage temperatures to determine the optimum cold storage conditions and the approximate storage life. Fruits were examined at regular intervals for ripening, changes in acids, sugars, respiration behaviour etc. Fruits stored for 15 days at 32-35°F, when transferred to ripening temperature (67-70°F), ripened normally after 8 days of storage. However, *sapota* stored for over two weeks at 32-35°F did not ripen satisfactorily. Fruits stored at 67-70°F ripened normally in 8 days time and the other lots stored at room temperature ripened in 6 days time. Further work is in progress to control storage diseases of *sapota*.

1.9.5 *Mangoes for pickling*: Mangoes of pickling variety were harvested from the local orchard and stored at different storage temperature conditions to determine the optimum storage temperatures and the approximate storage life. Mangoes stored at 32-35°F came down with physiological injury *i.e.*, surface discolouration in 3-4 weeks time. Fruits stored at 47-50°F and above ripened in 3-4 weeks time, while those stored at 39-42°F and 42-45°F kept very well for 2 months. The original texture, colour and flavour were maintained in mangoes stored at 39-42°F with 85-90 per cent R.H. and were acceptable for pickling purposes. Fruits were also treated with various concentrations of wax emulsion and stored at the above storage temperatures. 6 per cent wax emulsion has been found to be optimum for treatment of mangoes meant for pickling purposes. Such treated fruits, stored at 39-42°F, were better from consumers' acceptability point of view, even after 10 weeks of storage. Further work in this line is in progress.

1.10 Freezing preservation

1.10.1 *Mangoes*: Mature fruits of *Alphonso* variety from the local orchard were ripened in the laboratory at room temperature. Ripe and firm fruits were peeled, sliced and slices packed in polyethylene bags of 300 gauge, sealed, frozen at -20°F and subsequently stored at 0°F. Periodical observations were recorded in order to assess the consumers' acceptance. Mango slices thawed in the sugar syrup (50°brix) containing 0.5 per cent citric acid and 0.05 per cent ascorbic acid were found to be as good as those thawed in a syrup of 50°brix containing 1 per cent citric acid and 0.5 per cent ascorbic acid. These lots were compared with the

slices frozen in sugar syrup of the same formulae. No pronounced difference could be observed between the slices frozen in polyethylene bags, which were subsequently defrosted in the sugar syrup and those frozen in the sugar syrup in glass jars.

1.10.2 *Mango pulp:* Mango pulp was made from over-ripe fruits of *Alphonso* variety and packed in polyethylene bags of 300 gauge and sealed, as well as in glass jars. They were frozen at -20°F and stored at 0°F for further observations. Observations were recorded at regular intervals by drawing the frozen samples, thawed and mango juice and squash were made from such frozen pulp. Accelerated thawing of pulp made the products somewhat brown as compared to the pulp thawed at normal conditions. Further work in this line is in progress.

1.10.3 *Banana puree:* Fully ripe *Cavendish* banana fruits were obtained from the market for experimental purpose. Ripe fruits were peeled and pulped for frozen storage studies. In order to control browning of the pulp during pulping process, optimum brix and pH were standardized and an antioxidant was used. Out of the number of trials carried out, increasing the brix of the pulp to 30° by the addition of sugar, fixing the pH at 4 and addition of ascorbic acid at the rate of 300 mg. per kg. of the pulp during pulping process has been found to be satisfactory. Banana puree prepared in this way was frozen at -20°F in glass jars and subsequently stored at 0°F . After 8 months of storage at 0°F , banana puree thawed under the normal conditions, retained its original colour, flavour and taste. Various other biochemical changes like, changes in sugars, acidity, vitamin C, pH and colour changes if any, are recorded at monthly intervals, after the banana puree had been defrosted at normal room temperature conditions. Further work in this line is still in progress.

1.10.4 *Cauliflower:* Sound cauliflower heads were obtained from the local market for the experimental purpose. The heads were cut into small pieces of convenient size and one lot was steam blanched and the other lot was water blanched. Such blanched cauliflowers were packed in polyethylene bags of 300 gauge and sealed. They were subsequently frozen at -20°F and stored at 0°F for periodical observations. Samples drawn at regular intervals and thawed at normal room conditions were examined for consumers' acceptability regarding changes in texture, flavour, etc. It has been found that, after 3 months of storage at 0°F and subsequent thawing at normal room conditions, steam blanched cauliflowers maintained the original flavour, colour and texture and were better than the water blanched ones. Further work in this line is in progress.

1.10.5 *Green peas:* Tender peas were obtained from the market and depodded. One lot of pea pods was steam blanched and the other lot was water blanched for 10 minutes, while the third lot was blanched

in a solution containing 0.25 M concentration of $\text{Ca}(\text{OH})_2$ and 0.02 per cent alum to fix the chlorophyll and to maintain the original green colour. The blanched pea seeds were immediately cooled in cold water maintaining a temperature of 32-35°F. They were subsequently drained and packed in polyethylene bags and sealed. Sealed bags with the pea pods were frozen at -20°F and subsequently stored at 0°F for periodical observations. The samples were drawn at monthly intervals for observations regarding texture, colour and flavour. Peas blanched in a solution containing $\text{Ca}(\text{OH})_2$ and alum maintained better colour than those treated otherwise (the other two treatments). However, these peas were slightly soft and shrivelled. Peas, blanched in steam and immediately cooled in cold water, maintained better flavour though the colour was slightly inferior. Peas treated this way were quite acceptable after a long storage at 0°F. The experiment is in progress.

1.10.6 Pineapple: Mature, firm and fully ripe pineapples were peeled, cored and rings were blanched before freezing them in polyethylene bags of 250 gauge. The effect of water and steam blanching on the storage behaviour of frozen pineapple was compared with that of the control. Periodically, the samples were drawn and thawed at room temperature, in sugar syrup of 40°, 50°, 60°brix and in sugar syrup of 50°brix containing 1 per cent citric acid and 0.5 per cent ascorbic acid.

Consumers' acceptance trial has shown that the unblanched pineapple rings have been keeping very well till now, maintaining their near to natural flavour, texture and taste. It has been further found that thawing in sugar syrup containing citric acid and ascorbic acid is better than thawing without sugar syrup.

1.11 Fatty food storage

1.11.1 Cashew kernels: Studies were conducted on the role of moisture content and method of application of antioxidants. The technical 'Know-how' regarding deep fat frying of cashew kernels has been released to three firms. Further work on use of different antioxidants and packaging studies are in progress.

1.11.2 Groundnut kernels: Trials have been conducted to evolve an improved and cheap method of roasting groundnut kernels and to find means of prolonging their storage life. Seed coats of the fresh sun dried groundnut kernels were removed and the latter subjected to boiling for sometime in water containing various concentrations of salts and sugars. They were then dried and roasted at different temperatures for different periods.

Organoleptic tests have shown that the product has good taste and flavour. However, slight bitterness was noticed after this treatment. Storage studies are in progress. Modification of the method with various concentrations of salt and sugar in water at various temperatures, roasting at different temperatures and use of different antioxidants are in progress.

1.12 Physiological changes in fruits and vegetables during growth and development

1.12.1 Role of respiration rate on development of carotenoid pigments during ripening of tomatoes (*Lycopersicon esculentum*): Freshly harvested, green, fully mature tomato fruits from plants of same age and variety, grown on uniformly manured plots were taken, graded according to size and divided into 3 lots. One lot was left as such to serve as control, the other was treated with 6 per cent wax emulsion containing 0.5 per cent fungicide (SOPP) and the third was given a coating of mineral oil (Prerox 'D'). Changes in physiological losses in weight (PLW), acidity, respiration rate, carotenoid and chlorophyll contents in these fruits during ripening at room temperature (75-92°F) were studied.

The results obtained indicate that treated tomatoes show less PLW and lower respiration rate. The changes in acidity in the treated ones show a decrease during ripening over the initial value, while, in the control, the acidity showed fluctuations over the initial, always being higher than the treated ones. The degradation of chlorophyll is faster in the untreated tomatoes than treated ones. The changes in carotenoids indicate that the rate of development of carotenoid pigments in tomatoes is slower in treated than untreated ones.

It has been concluded from the results that respiration rate influences both the degradation of chlorophyll and the development of carotenoids. The rate of carotenoid development is dependent on the rate of respiration, which will be influenced by the generation of ATP and may also be through some other means like providing precursors for the synthesis.

1.12.2 Physical and biochemical changes in guavas during growth and development: Physical and biochemical changes in four varieties of guavas viz., *Allahabad*, *Safeda*, *Banaras* and *Seedless*, were observed. The data obtained have indicated that, immediately after fertilization until 45 days, a very rapid growth in the fruits was observed, from 45th day to 75th day the growth rate decreased followed by a rapid rate of growth which is maintained till the fruit matured. All the four varieties maintained the same pattern, but the best growth was observed in *Banaras* variety and the least growth in the *Seedless* variety which came to maturity earlier than the other varieties.

There was a very slow rate of accumulation of vitamin C till 90 days but from then onwards the rate of accumulation increased. Respiration of the fruits was very high in the early stages, showed a gradual decline and reached a constant level, showing a slight drop in acidity at the maturing stages. Tannin content was high at the beginning, gradually decreased to a very low value at the fully mature stage.

1.12.3 Physical and biochemical changes in limes during growth and development: The changes in length, breadth, weight and specific gravity indicate that, immediately after the flower formation upto 90

days, there is rapid growth and, from 90 to 120 days, the rate of growth shows a slight slackness and from 120 to 180 days the maximum growth is achieved. This indicates that the rate of growth fluctuated probably due to a variation in the auxin content of the fruit during growth besides nutrition of the trees.

The acidity does not show significant increase upto 90 days. From 90th day onwards, it increases reaching a maximum by 180 days. The changes in the pectin content shows that the total pectin is high upto 120 days from then onwards it decreased. Initially the water soluble pectin was found to be high, but, as the fruit matures, the oxalate soluble fraction increases and the acid soluble fraction remains almost the same. The percentage of tannins is high in the beginning and gradually declines as the fruit matures. Respiratory rate is very high in the beginning and decreases gradually.

1.12.4 Influence of mineral oil (Prerox 'D') coatings to guava fruits on respiratory activity and chemical constituents during ripening at room temperature (75-92°F): Freshly harvested, mature, hard and green guavas were obtained from the Institute orchard and divided into 8 lots. They were treated at different regions with mineral oil as follows: (1) control, (2) top $\frac{1}{3}$, (3) middle $\frac{1}{3}$, (4) bottom $\frac{1}{3}$, (5) top $\frac{2}{3}$, (6) bottom $\frac{2}{3}$, (7) top $\frac{1}{3}$ + bottom $\frac{1}{3}$, and (8) fully coated. The fruits were kept at room temperature and their respiratory activity, physiological losses in weight, vitamin C, sugars and acidity were determined periodically.

The respiration rate was greatly decreased immediately after application of oil in all the fruits. In the fully applied fruit, the respiration rate remained low throughout and the colour of the fruit remained green even after 7 days while the control ones ripened fully in 4 days. The respiratory activity in the fruits which were given the other treatments, though showed a climacteric rise, was a little delayed and not as high as that of the control. Retention of vitamin C was better than in the control. The total sugars decreased slightly in the treated fruits, but the reducing sugars were higher than the non-reducing sugars in the treated fruits, compared to the control.

1.13 Mushroom technology

1.13.1 Cultivation of *Pleurotus* sp: (a) Effect of different temperatures on yield of mushroom was studied by keeping the beds at different temperatures *viz.*, R.T., 60-70°F, 52-55°F and 100°F, 98 per cent R.H. The yield of 175 g. per foot square was obtained on the beds kept at room temperature under Mysore conditions.

(b) Barley, wheat, rice, corn, *jowar*, *bajra* and *ragi* were tried, in powder form in the beds and were compared with oatmeal which was found effective in earlier experiments. *Bajra* proved to be the best among the cereals and the yield of mushroom was 148 g. per foot square on

fresh weight basis, though addition of oatmeal gave an yield of 219 g. per bed.

(c) In another set of experiments, all the pulses were tried as sources of nutrient in the beds. In order to make the pulse protein readily available to the ramifying mycelium, pulse extracts in water were used in the beds, but it did not produce any significant results on the yield.

The straw was steamed for half an hour and then used for making of beds. The straw became susceptible to microbial attack and the yield was quite low.

1.13.2 Storage studies of spawn: Spawns were stored at R.T., 32-35°F and 60-70°F for 15 days to one year. Spawns stored at 32-35°F for 10 months had lost their viability. The spawns stored for 2-8 months at this temperature gave a poor yield. The yield was very low when the spawns stored at 47-50°F for 10, 8, 6, 4 and 2 months, were used. Four months old spawn stored at R.T. gave the maximum yield.

1.13.3 Large-scale cultivation of *Pleurotus* sp: After standardising the conditions for cultivations of *Pleurotus* sp. on paddy straw, large-scale trials were conducted to work out the tentative economics of large scale cultivation. One foot square beds were made in large numbers on bamboo racks and inoculated with spawn. The average yield of the mushroom per bed was nearly 250 g.

1.13.4 Canning of mushrooms: Mushrooms were canned in 5 oz. plain cans with 2.5 per cent sugar and salt solution. Cans were exhausted, sealed and processed at 15 lb. pressure for 20 minutes. The following treatments were tried to retain flavour and colour in canned products: (1) monosodium glutamate (MSG) 0.2, 0.3 per cent, (2) citric acid—0.14 per cent, (3) MSG + ascorbic acid in 0.3 and 0.14 per cent respectively, (4) citric acid 0.25 + ascorbic acid 0.3 per cent and (5) meat extract 0.2 per cent.

The cans were stored for six months at room temperature and organoleptic tests carried out. Monosodium glutamate 0.3 per cent, MSG + 0.14 per cent ascorbic acid, and 0.2 per cent meat extract gave good results, as evidenced by the relation of mushroom flavour and natural colour.

1.13.5 Dehydration of mushrooms: Sun-drying, oven-drying at 60°C, vacuum drying, freeze drying and sponge dehydration were tried to dehydrate mushrooms. Sponge dehydration technique gave good results permitting the retention of the flavour and natural texture. The material kept well for 6 months.

1.13.6 Chemical analysis of fruit bodies: The chemical analysis, on fresh weight basis, of fruit bodies is as follows: ashing of the material was done in muffle furnace at 500-550°C; moisture 90.95 per cent; ash content 0.973 per cent; phosphorus 0.105 per cent.

Niacin was estimated by Swaminathan's method and found to be 5.5 mg. per cent. Thiamine was estimated by thiochrome oxidation method and was found to be 0.13 mg. per cent. Ascorbic acid was estimated by titration method and was found to be 9.22 mg. per cent.

Protein was estimated by Kjeldahl's digestion unit and was found to be 2.4-2.7 per cent containing 17 amino acids as identified by circular paper chromatography. Confirmatory tests were also done. The amino acids present were leucine, isoleucine, phenylalanine, valine, methionine, serine, glycine, asparagine, arginine, lysine, histidine, cystine, tryptophan, tyrosine, proline, threonine and glutamic acid.

Quantitative estimation of essential acids was done by microbiological assay technique. The results are presented below on protein percentage basis:

Leucine	4.4 per cent	Tryptophan	0.9 per cent
Isoleucine	5.2 „	Threonine	4.2 „
Phenylalanine	2.0 „	Arginine	6.7 „
Valine	4.6 „	Lysine	5.0 „
Methionine	1.2 „	Histidine	2.1 „

The results indicate that mushroom protein is better than any other vegetable protein, though it is deficient in methionine and phenylalanine, yet it contains other amino acids in high concentration in comparison to egg protein. If supplemented with cereal diet, it may serve as a good protein food. Further work on biological value and protein efficiency ratio is in progress.

The NPN, as estimated by taking 10 per cent trichloroacetic acid extract which was digested in Kjeldahl's digestion unit was found to be 1.55 per cent on dry weight basis.

For free amino acids, 70 per cent alcohol extract was used for spotting chromatography and it was found to contain all the amino acids and one peptide.

1.13.7 Cultivation of *Lepiota* sp: The culture of *Lepiota* sp. was purified and a number of media tried *e.g.*, PDA, nutrient agar, horse dung medium, PDA+carrot extract, oat meal and malt agar. Of them, PDA proved to be the best. The spawns were prepared on different media *i.e.*, horse dung, soil, composted horse dung, saw dust, wheat, *jowar* and paddy grains. The best growth was observed on paddy grain spawn.

Lepiota sp. was grown on horse dung manure in green house using for cultivation of paddy grain spawn. Yield was very low because the beds got contaminated with mould, bacteria and insects.

1.13.8 Submerged propagation of mushroom: *Pleurotus* mycelium was grown on different organic media and yield of 14-17.5 grams per litre on dry weight basis was the highest on PDB.

(a) SUPPLEMENTATION OF ORGANIC MEDIA

Organic media, rich in carbohydrates when used for submerged propagation of mycelium, did not give a good yield unless they were supplemented with cheap protein source. For this reason the yield was found to be poor in tapioca-dextrose medium and, therefore, the medium was supplemented with groundnut cake extract, in 1, 2, 3, 4 per cent concentrations. There was an increase in the yield from 3 g/l. to 14 g/l. Even the protein content of mycelium increased from 14 per cent to 38 per cent on dry weight basis.

On further increasing the concentration of groundnut extract in the medium, the groundnut extract got precipitated and settled down at the bottom and there was no increase in the yield.

Large-scale trials were done in 4 litre culture flasks taking one litre of medium. It was noticed that there was an increase in the yield of mycelium per litre of medium used from 14 g. to 20 g. of dried mycelium/l.

(b) SUPPLEMENTATION OF POTATO-DEXTROSE BROTH

The potato-dextrose broth was supplemented with asparagine in different concentrations to see the latter's effect on protein content of mycelium. As the quantity of asparagine was increased in the medium from 0.04 to 0.1 per cent, there was an increase in protein percentage of mycelium from 24 per cent to 28 per cent on dry weight basis. On further increasing the concentration of asparagine in the medium, there was no change in protein percentage.

(c) SYNTHETIC MEDIUM

For obtaining accurate information on the nutrient requirement of mycelium, synthetic medium was used during the investigation. The growth of the mycelium was not so good on synthetic medium as compared to organic medium and the yield was quite low.

(d) EFFECT OF DIFFERENT NITROGEN SOURCES ON YIELD

Tapioca-dextrose medium was supplemented with various nitrogen sources *e.g.*, amm. sulphate, amm. nitrate, urea, asparagine, amm. tartrate, etc. Asparagine and amm. tartrate gave better results, but the yield was quite poor as compared to control (PDB medium). The medium was supplemented with vitamins, trace elements and pH was adjusted, at different levels, to see whether it would affect the uptake of inorganic nitrogen by mycelium. The results were not very encouraging. Further work is in progress.

(e) EFFECT OF INCREASING THE SOURCE OF CARBON ON YIELD

Glucose was added in different concentrations and it was found that the yield increased by increasing the concentration of glucose from 1-5

per cent. Maximum yield was obtained when 5 per cent glucose was used.

The chemical analysis of the mycelium has been found to be as follows: protein, 30.4 per cent; ash content, 10.8 per cent; nicotinic acid, 61.1 mg/100 g.; ascorbic acid, 102.5 mg./100 g.

The amino acids of the protein were identified by circular paper chromatography and their confirmatory tests done. Altogether, there were 17 amino acids including all the essential ones. Amino acid composition of mushroom mycelium was done quantitatively by microbiological assay and it was found to be the same as that of mushroom protein.

The NPN was estimated by taking trichloroacetic acid (10 per cent) extract. The extract was concentrated and nitrogen estimated by digesting it in Kjeldahl's digestion apparatus. 1.55 per cent NPN was estimated. It was found that the NPN contained all the amino acids and one peptide. The free amino acids were also identified by circular paper chromatography.

1.14 Transportation of perishables

Wax formulations evolved at the Institute were tried on a number of commodities. The treated and untreated lots were transported (using the packages and transportation systems in vogue) to distant consuming centres. At the receiving end, the percentages of wastage after transportation and the post-transportation life of the commodities were determined. It was found that the skin coating aids in reducing the spoilage during transportation and extending the post-transportation life. The spoilage after transportation was reduced as follows: mangoes from 40 per cent to 14 per cent, *Golden Delicious* apples from 70 per cent to 15 per cent; *Granny Smith* apples from 40 per cent to 9 per cent; oranges from 35 per cent to 8 per cent and limes from 40 per cent to 10 per cent. Large-scale trials on waxing of *Cavendish* banana and shipping to Middle East countries have given encouraging results. The treated fruits, owing to slow metabolic changes as a result of skin coatings, acquire resistance against microbial and physical spoilage thus showing a marked decrease in the overall wastage during and after transportation.

Large-scale trials on application of the growth regulators were studied in relation to transportation of perishable commodities. In the case of onions in which rooting, sprouting and microbial spoilage due to *Rhizopus* sp. are very common, it has been found that a foilage spray of 400 p.p.m. MH, fifteen days prior to harvest, inhibited rooting and sprouting and also reduced microbial spoilage during and after transportation. Application of 2: 4: 5-T and 2: 4-D, has given good results on *Blood Red malta* and *Golden Delicious* apples. It was found that in the case of *Blood Red malta*, there was no significant difference between treatments of 2: 4-D and 2: 4: 5-T, but the fresh appearance was maintained for a long time in the fruits treated with 2: 4: 5-T, probably because it slowed down the

change of colour. Based on 90 per cent marketability it was found that the spoilage in onions was reduced from 20 per cent to 8 per cent and post-transportation life increased from 25 days to 80 days. In *Blood Red malta*, the spoilage was reduced from 25.5 per cent to 9 per cent and post-transportation life increased from 12 days to 23 days. Further work on grapes, pineapples, mandarin oranges, guavas, mangoes etc., is in progress.

1.15 Steeping preservation

Storage of fresh fruits and vegetables in the garden fresh condition by a reliable but low cost method that can readily be adopted at the village and marketing centres is of great necessity and importance in this country. The desired protection against microbial and physiological changes have been achieved in peas and grapes by treatments which can reduce microbial load and subsequent storage by continuous steeping in low levels of mixed preservatives.

1.15.1 Peas: In the preliminary experiments, two days old fresh peas were brought from the market. They were depodded, washed and pre-treated in a solution maintained at pH 8 by the addition of 2 per cent sodium carbonate and 0.02 per cent alum for one hour. They were then graded into floaters and sinkers and the graded peas were separately treated. They were then subjected to blanching in the solution of 0.02 M. calcium hydroxide (pH 8) for 2 minutes in boiling water. After blanching and cooling, peas were kept in a steeping solution of salt, sugar, potassium metabisulphite, potassium sorbate and magnesium sulphate. In addition, copper citrate and potassium hydrogen phthalate were also tried to retain the chlorophyll content during storage.

The peas were steeped in the above solution for 12, 24 and 36 hours. They were then taken out and packed in polyethylene bags (200 gauge) and kept at two temperatures, *viz.*, 32-35°F. and 85-90 per cent R.H., and room temperature (79-84°F, 52-65 per cent R.H.) The bags were opened at regular intervals and the green colour was measured both colorimetrically and visually. The organoleptic evaluation was conducted by a panel of judges for the fresh as well as cooked peas. They were also dehydrated and canned and the product was organoleptically evaluated.

In the control lot, where peas were kept at low temperature with and without pods, peas started germinating within two weeks and 3 days respectively. The steeped peas did not show any sign of fungal infection and were hard and firm. Peas steeped in solution containing salt—4 per cent, sugar—2 per cent, alum—0.02 per cent, magnesium sulphate—0.5 per cent, potassium metabisulphite—0.1 per cent, potassium sorbate—1.0 per cent, copper citrate—0.05 per cent and potassium hydrogen phthalate—1 per cent, kept very well for 6 months at 32-35°F and 85-90 per cent R.H. They were also organoleptically suitable both as fresh and cooked. Experiments on continuous steeping method also gave similar results, but peas steeped continuously for 4 months absorbed

comparatively higher quantity of potassium sorbate and potassium meta-bisulphite. It was, therefore, found that peas should not be steeped continuously for longer than 3 months.

There was no respiration recorded in the blanched and steeped peas, as measured by continuous current method. No germination was also recorded during the storage period. This shows that the enzymes in the peas are inactivated by blanching and steeping in the fluid. Blanched peas without steeping treatment showed low respiration rate. Further, germination was also noted and microbial spoilage was found to be very high. Therefore, it seems necessary that, after blanching, peas should be steeped in a solution containing potassium meta-bisulphite and potassium sorbate. In another set of experiments, where potassium sorbate was not used, microbial spoilage was noticed. This may be due to loss of SO_2 during storage.

After the preliminary experiments, field trials were conducted at Nilgiris where the crop was harvested, depodded, blanched and steeped within a period of 3-4 hours on the fields. In another set, peas were harvested and kept for 24 hours before depodding, blanching and steeping. In both the cases, peas could be kept for ever 6 months at 32-35°F and 85-90 per cent R.H. However, peas which were kept for 24 hours showed slight mellow taste as compared to peas which were treated just after the harvest. There were three replications and each replicate was of 300 kg.

The stored peas, after every month upto six months, were dehydrated both in vacuum and through-flow air drier. The dehydrated peas retained attractive green colour after dehydration and reconstituted well maintaining the colour and consistency. The stored peas were also canned successfully after a storage period of 6 months.

It was noticed that the peas, after storage, are partially dried by hot air blower at 120°F, could be kept for a longer time at room temperature but, in that case, the skin of the pea would wrinkle and the colour fade during storage at room temperature.

1.15.2 Grapes and litchies: Freshly harvested grapes were kept for a period of 8 months in sugar solution of 30-35° brix, containing 0.5 per cent citric acid, 0.1 per cent ascorbic acid, 1 per cent potassium sorbate and 0.2 per cent potassium metabisulphite. Similarly *litchies* were also kept for over 4 months in a similar solution. The taste of the fruits kept under such conditions improved and the flavour was retained. The absorption of potassium sorbate and potassium metabisulphite in the stored products has been within the permissible limits. Further work in this direction is in progress.

2. Infestation Control and Pesticides

2.1 Control of insect infestation under warehouse conditions

2.1.1 Behaviour of ethylene dibromide—methyl bromide mixtures at different temperatures: Further studies were carried out on ethylene dibromide and methyl bromide mixtures of different proportions (0, 5, 25, 50, 75, 100 per cent of methyl bromide), applied in columns of wheat semolina and *jowar* at different temperatures, 68°, 77°, 100°F. The results of the trials indicated that, at lower temperatures, the proportion of methyl bromide to ethylene dibromide should be increased for relatively better toxicity and distribution, while at higher temperatures, proportion of ethylene dibromide to methyl bromide should be increased to obtain higher degree of toxicity to insects and uniform distribution of fumigants. It was noted that, at 100°F in semolina columns, the rate of reaction of methyl bromide with semolina increased considerably as compared at 68°F resulting in higher residues. Intergranular concentration was lower at 100°F as compared to 77°F. Further studies are in progress with reference to the mechanism of lowering of toxicity of methyl bromide to insects at higher temperatures such as 100°F and above. Due to the propellency and carrier action of methyl bromide, ethylene dibromide got itself eluted to the bottom of semolina columns. The separation of the components in semolina columns was more than that in *jowar* columns. This tended to change the ratio of the components applied initially. Enrichment of ethylene dibromide at the top portion and partial stratification of methyl bromide at the bottom portion of the columns were noted. Complete separation of the two gases was not obtained under the conditions of study.

2.1.2 Warehouse trials on minimal dosage and efficiency of gas proof sheets: Large-scale trials were carried out in the warehouse to determine the lowest dosages required for fumigation with methyl bromide and mixture of ethylene dibromide and methyl bromide.

Dosages ranging from 8 mg./1 to 32 mg./1 were tried in the experiment. In general, the gas concentration data, mortality of the test insects, *Tribolium castaneum*, *Ephestia cautella*, *Bruchus chinensis*, *Trogoderma granarium*, *Corcyra cephalonica*, *Sitophilus oryza* and bromide residues in the materials indicated that 16 mg./1 dosage of the 1:1 mixture of ethylene dibromide and methyl bromide was superior to 16 mg./1 dosage of methyl bromide alone. It was observed that the transmission of the fumigant through the fabric used as gas proof sheet for fumigation, increased with the higher concentration of methyl bromide and the temperature of the environment. At temperatures above 25°C, the

transmission and escape of methyl bromide from the gas-proof sheet made of rubberised fabric, and 1,000 gauge polyethylene was quite high. A very low concentration of methyl bromide could be detected after 24 hours of exposure, while 1:1 and 1:2 mixtures of ethylene dibromide and methyl bromide could give significantly higher concentration even after a period of 48 hours. The retention of the fumigant inside the gas proof sheet increases considerably with the mixture, which became marked at 25°C and above.

Experiments were carried out with cherry and Plantation coffee stacks infested by *Araecerus fasciculatus* under the commercial warehouse conditions with a view to examining the polyethylene sheets (1,000 gauge) for their suitability for fumigation. Data were collected on fumigant retention under gas proof covers with the 1:1 mixture of methyl bromide and ethylene dibromide, in large-scale fumigations. The test materials were: (i) 1,000 gauge high pressure polyethylene single sheet, (ii) 1,000 gauge high pressure polyethylene double sheet and (iii) rubberised fabric.

The results have indicated that the ordinary high pressure polyethylene used in the trial is not suitable for use as a cover for fumigation at high temperatures as obtained under the experimental conditions (24—28°C). Rubberised fabric was more suitable for commercial fumigation than the low density polyethylene sheet.

2.1.3 Durofume applicator: The applicator for fumigation with different proportions of ethylene dibromide and methyl bromide required under the warehouse conditions was designed and the technique of fumigation with the equipment has been standardised.

2.1.4 Stratification of fumigants: Tall columns of 12' were commissioned for screening of fumigant mixtures with and without load. Preliminary trials with the combinations of sulphur dioxide and carbon dioxide and methyl bromide, ethylene dibromide and freon have been initiated.

2.1.5 Fumigation of oil bearing seeds: Further work was carried out on the fumigation of oil bearing seeds such as copra, groundnut and cashewnut, with ethylene dibromide, methyl bromide, chloropicrin and ethylene oxide. Detailed work is in progress on the assessment of the fumigant residues in respect of ethylene dibromide and 1:1 mixture of ethylene dibromide: methyl bromide, on defatted cashew-nuts, copra and groundnut meal. Previous studies indicated that the protein fraction of the seed was largely responsible for retaining the residue of methyl bromide. The oil fraction, on the other hand, absorbed ethylene dibromide and retained it for long period. Effect of high dosages of the fumigants on the extent of reaction with the amino acids in the oil seeds are being assessed by the microbiological assay and paper chromatography.

2.1.6 Disinfestation by heat treatment:

(In collaboration with Fruit Technology and Dietetics Divisions):

Experimental work on the heat disinfestation technique was carried out with special reference to the control of *Stegobium paniceum* in spices, *Bruchus chinensis* in pulses and *Tribolium castaneum* in Indian multi-purpose food. Data on the thermal death time were collected on different test insects. Experiments with infra-red heating and exposure in hot chamber and also steam heating in spin-pasteuriser were studied for disinfestation of spiced products, pulses and the multi-purpose food. Detailed studies on the effect of heat on the viability of seed, microflora and loss of vitamins are in progress.

2.2 Studies on insecticidal clays

2.2.1 Selection of raw clays for their amenability to activation treatment: Clays containing various proportions of kaolin, montmorillonite and illite, both raw and processed, acid activated as well as acid activated and heated to 400°C, were tested for their insecticidal activities with *T. castaneum* as test insects under standard conditions. The relative potencies, as exhibited by different samples, were compared. It was observed that all the clay samples, more or less, could be converted into comparatively better insecticidal material than the parent substances both by heat and acid activation treatments. Dehydration and rehydration characteristics of the clays, which had very high insecticidal potencies and also retained the property even on storage after the activation treatment, indicated the predominance of kaolin in contrast with other clay constituents. Studies on the mode of action of different types of acid activated clay samples showed that the lipid removal from the insect cuticle was the essential factor responsible for the insect mortality. This lipophilic property was independent of the moisture content of the acid activated insecticidal clays. But, the death time of the insect was governed, to a large extent, by the relative humidity of the microclimate. All the samples examined indicated that the oil bleaching property, gas absorbing capacity and other criteria of activation were related to the degree of insecticidal action.

2.2.2 Effect of initial particle size of the clay on the insecticidal activity as induced by activation treatment: Insecticidal activity of the fractions retained on 85 mesh and passing through 85, 100, 200 and 300 mesh sieve were activated by acid activation treatment and compared for their insecticidal potencies. It was observed that there was a tendency for the particles to break down further during acid activation and also heating at 400°C, in the post-activation period. There was very little difference in the insecticidal potencies of the different fractions treated similarly with respect to activation. The samples heated at 400°C, in the post-activation period, always showed higher insecticidal activity than those given the usual acid activation treatment and drying at 110°C. The related aspects are under investigation.

2.2.3 *Standardization of conditions for pilot-scale production of insecticidal clays:*

(In collaboration with Engineering Division)

Studies are in progress on the feasibility of large-scale activation of clays for their use as insecticides. The conditions which were found to be optimum for production of insecticidal substances from the kaolinic clays are being examined for their applicability in pilot-scale production. This work will be carried out in collaboration with the Regional Research Laboratories, Hyderabad. At this Institute, acid activation treatment in wooden vats is being studied for its practical utility.

2.2.4 *Relationship of the cation replacement of the clays with their insecticidal properties:* By the process of acid activation treatment, the methylene blue absorption value is considerably lowered and the b.e.c. also goes down. Major amount of cations are replaced by hydrogen, giving rise to largely H-clay. Although the insecticidal activities of the acid activated clays are comparable to DDT, the mortality of the insect seems to be lowered under high relative humidity conditions (83 per cent RH and above). Attempts are being made to replace some of the cations of the clay particles for exerting their effect on insects even under high humidity conditions. Hydrogen of the activated clays was replaceable by sodium, potassium, iron, copper, cobalt, manganese, magnesium, mercury, zinc and barium. The insecticidal activity of the resultant materials are being studied for their relative insecticidal potencies under high humid conditions.

2.2.5 *Activated clays as carriers for fumigants and insecticides:* Ethylene dibromide, carbon tetrachloride, DDT and lindane were incorporated at various proportions in the activated and unactivated Bageshpura clay. The results, in general, suggested that the activated clay action was independent of the effects of lindane and DDT on insects. As compared to DDT and lindane used in the form of fine dust without a carrier on the mortality of *T. castaneum*, it was observed that activated clay tended to reduce the toxicity of DDT and lindane when it was used as a carrier. Unactivated clay samples used as control, on the other hand, seemed to be better carriers of the insecticides. Fumigants or solvents which were more volatile than the insecticides, such as lindane and DDT, enhanced the insecticidal action of the clays. Absorption of ethylene dibromide, xylene and benzene on the activated clay particles enhanced the insecticidal effect of both activated and unactivated clays. Further, there was progressive decrease in the increased insecticidal action on aeration of the clay containing the sorbed fumigants. Detailed studies on the practical utility of the residual fumigant on the activated clays are in progress.

2.2.6 *Dilution of insecticidal clays with inert carriers:* Further studies were carried out on the use of the activated insecticidal clays

themselves as active ingredients with other inert diluents. The activated Bageshpura clay was diluted with dry soil, sand, unactivated clay and corn starch at 0, 25, 50 and 100 per cent levels. It was observed that the diluents had very little, or no effect on the insect mortality, whereas at 25 per cent concentration of activated clay in soil, sand, corn starch and unactivated clay, it gave significant insecticidal action on *T. castaneum*. At 50 per cent level (in the diluent), the insecticidal activity was as high as that of the hundred per cent activated clay.

The results of this experiment indicated that the activated clay could be used as the active ingredient in inert carriers as an insecticidal dust.

2.2.7 Infiltration of *Sitophilus oryza* and *Tribolium castaneum* through fabrics: Infiltration time for these insects through fabrics of cotton, nylon, jute and flax having different weave clearances were recorded. In further experiments, activated clay was used at 1.2 g./sq. ft. on the fabric surface, for assessing its ability to prevent infiltration of the adults and also oviposition through the weave clearance on the grain. In general, the dusting of activated clay on the surface of the fabric reduced the penetration of the adults through the fabrics.

2.3 Hermetic storage and gaseous sterilization of grain

2.3.1 Effect of temperature on the sporicidal action of fumigants on microflora of *Sorghum*: Methyl bromide, ethylene dibromide, ethylene oxide, chloropicrin, mixture of ethylene dibromide and methyl bromide, propylene glycol, formaldehyde, ethyl formate, EDCT, carbon tetrachloride, carbon disulphide, chloroform, acrylonitrile and ethylene dichloride were tested for their fungicidal and bactericidal effects at 25° and 37°C with dosages of 64, 96 and 192 mg./l and 96 hours exposure period.

Chloroform, carbon tetrachloride, EDCT and ethylene dichloride did not show appreciable fungicidal or bactericidal actions excepting a little inhibitory action on yeast. Propylene glycol and ethylene dibromide exerted fungicidal property at 64 mg./l and 96 mg./l concentrations respectively. Bactericidal action was not exhibited by these two fumigants at 37°C and 96 hours exposure. Complete sterilization of *Sorghum* was obtained with formaldehyde at 8 mg./l at 25°C and ethylene oxide and ethylene dibromide-methyl bromide mixture at 37°C with 192 mg./l and 96 mg./l respectively. Ethylene oxide, acrylonitrile and formaldehyde affected the germination capacity adversely even at 25°C. Although methyl bromide, when used alone, inhibited the viability of the seed, the mixture of ethylene dibromide and methyl bromide did not affect this property.

The results of this trial seem to indicate that the partial sterilization which is required for preventing the spoilage of grain stored in bulk can be obtained with some of the fumigants tested. Combinations containing ethylene dibromide, methyl bromide and chloropicrin and ethylene oxide and carbon dioxide seem to be promising.

2.3.2 Action of a mixture of ethylene dibromide and methyl bromide on the storage of moist Sorghum in out-door metal and cement concrete structures: Grains, with initial moisture contents of 15 and 20 per cent, were stored in one ton capacity metallic bins and were subjected to the atmospheric temperature fluctuations (23-34°C). In the experimental lot, 1:1 mixture of ethylene dibromide and methyl bromide was used at 96 mg./l dosage to exert the microbicidal action on the grain. Data were collected on the temperature changes and carbon dioxide concentrations during the storage period of 150 days. At the end of the experiment, analysis was carried out on the samples drawn from the control and treated bins on the following: insect count, kernel damage, frass content, uric acid, water soluble acidity, amino nitrogen, reducing sugar, fat acidity, microbial count, moisture content, odour and organoleptic quality. Bromide residues were also estimated in the samples.

The results of this trial pointed out to the fact that temperature fluctuation accelerated the process of the condensation of moisture, and development of temperature gradient in the bulk. Out-door structures exposed to the temperature fluctuation, gave rise to condensation of moisture and building up of steeper temperature gradient depending on their thermal conductivities. Cement concrete structure, which has lower thermal conductivity than the metal structure, gave rise to least difference in the moisture gradients in the bulk. The beneficial effect of the fumigant combination on the storage quality of the grain could be exerted due to the reduction in the activity of microorganisms in the high moisture pockets. Results indicated the possibility of utilising the principles of aseptic and hermetic storage of foodgrains by controlling the spoilage due to moulds and insects in metallic and cement concrete structures.

2.3.3 Experiment on in-package gaseous sterilization: In-package fumigation is required for some packaged cereal products, confectioneries, dry fruits and dehydrated vegetable and animal products. Transmission of fumigant vapours through the bags of polyethylene (high and low pressure), cellophane and polycel (polyethylene and cellophane combination) were studied. The following fumigants were tried: ethylene dibromide, methyl bromide, mixture of ethylene dibromide and methyl bromide, chloropicrin and ethyl formate. Cellophane and polycel were found to be superior to polyethylene for retaining the fumigant. Low pressure (high density) polyethylene retained the gases for longer periods than the high pressure (low density) polyethylene. Out of all the fumigants tested, ethyl formate was retained for the longest period. It was interesting to note that both chloropicrin and ethylene dibromide (which are high boiling and low vapour pressure fumigants) escaped at quite high rates through all the films. Although ethyl formate is of lower boiling point and higher vapour pressure than chloropicrin and ethylene dibromide, it gave the highest retention and concentration-time product.

Compatibility of ethyl formate with chloropicrin and ethylene oxide is under investigation, for obtaining in-package sterilization of microflora and insects.

2.3.4 Gaseous sterilization of arecanut:

(In collaboration with Arecanut Technology Unit)

Attempts were made to utilize gaseous sterilants in aqueous medium for inhibiting the microbial spoilage of raw arecanuts by steeping. Further trials were carried out on the effect of fumigation of the raw arecanut which were pre-treated in potassium metabisulphite solution and packed subsequently in heat sealed polyethylene bags. In-package gaseous sterilization in polyethylene bags was also carried out. The results of the experiment indicated that the degree of initial infection of the raw nut exerted a critical effect on the effectiveness of the above treatments. The following were studied in gaseous and dissolved state: methyl bromide, chloropicrin, ethyl formate, sulphur dioxide, formaldehyde and ethylene oxide. The approach made in this trial (*i.e.*, in-package sterilization of raw arecanuts) seems to be highly promising.

2.4 Studies on malathion as grain protectant

2.4.1 Pre-harvest prophylaxis for post-harvest storage: Large-scale trials on the pre-harvest prophylactic treatment were carried out with malathion and pyrethrin. Water dispersible formulations of pyrethrin and malathion were sprayed with low volume nozzles on ripe panicles in 3-acre plots. Insecticidal analysis, immediately after spraying and at the time of harvest, was carried out. Subsequent storage trial in insect-proof gunny bags showed that malathion was superior to pyrethrin with regard to the control of field infestation and protection from cross-infestation during the initial period of storage. The prophylactic effect of insect-proof gunny bags and the disinfestation by malathion treatment in the field condition could result in sound, insect free storage of *Sorghum* even in a heavily infested incubation room. The results of the study revealed that spraying of malathion at optimum level in the field condition, will ensure control of the stored grain pests attacking during the pre-harvest period in the field. Spraying of pyrethrin did not give adequate control of the field infestation. The results of the study indicated that the fumigation treatment could be totally avoided by the pre-harvest prophylactic spraying of malathion. Comparative data were obtained on insect count, fat acidity, uric acid, frass, water soluble acidity, reducing sugar and amino nitrogen on the experimental samples.

2.4.2 Studies on the effect of malathion in poor rice diet on growth and cholinesterase activity in rats: Malathion was mixed at different levels, even including a dosage as high as 100 times the permissible limit, and fed to rats for a period of 16 weeks. Effect of cooking on the malathion residues was also studied. The rats were fed *ad libitum* for a period of 4 months, at the end of which they were sacrificed and the analysis of

blood for cholinesterase activity and also histopathological changes, if any, in the vital organs was carried out. The result of the analysis showed that malathion even at 800 p.p.m. in diet added before and after cooking, did not bring about any deleterious changes on the growth or on the cholinesterase activity of plasma and erythrocytes of the blood.

2.4.3 Effect of particle size on the insecticidal efficacy of malathion: *Jowar*, rice and wheat were ground to different degrees and passed through various meshes. Bio-assay of the insecticide in different materials with 40 p.p.m. level, using *Tribolium castaneum* adults showed that the effectiveness of malathion increased with the increased in particle size.

2.4.4 Persistence of malathion on treated grain: Studies were continued on the persistence of malathion on treated grains and milled materials during storage and processing. It was found that, depending on the condition of storage, within 3 months there was 90 to 100 per cent destruction of malathion used at 8 p.p.m. level in wheat flour. There were 58 to 89 per cent destruction of malathion on cooking of *jowar*, wheat and rice. It appeared that boiling in water was much more efficient in decomposing malathion than the usual baking in the preparation of unleavened bread. Detailed studies are in progress on the degradation products of malathion by the application of paper chromatography and estimation of inorganic phosphorus.

2.4.5 Transfer of malathion dust from bag surface to grain: Collaborative trials were carried out with the Directorate of Storage, Government of India, on the assessment of malathion residues in grains. About 70 samples were drawn from treated stacks and analysed for the residual contamination in the grain due to the peripheral dusting treatment on the stacks.

2.4.6 Persistence of malathion and DDT residues on sprayed fruits and vegetables:

(In collaboration with Agri-Horticulture Section)

Very high population of the mango hopper *Ideocerus neviospersus* appeared on the mango blossoms. Water dispersible formulations of malathion and DDT were sprayed 1, 2 and 3 times consecutively at every 10 days' interval in different plants. The effect of insecticidal spraying on fruit drop, fruit size and yield were obtained on control and treated trees. Pesticidal residues were estimated on the skin and edible mesocarp of the fruit and also on leaves. Meteorological data were also kept during the experiment.

2.5 Stored grain pests and their food preferences

During the period under report, a new fundamental approach has been made for the control of stored grain pests based on their food preferences as factors for their control. Specificities with respect to food

composition and the particle size, for *S. oryza*, *T. castaneum*, *B. chinensis* and *S. paniceum* are being investigated. It is observed that *S. oryza* prefers cereals and pulses with particle size retained on 18 mesh. *T. castaneum* on the other hand prefers particle size below 40 mesh, for the growth and breeding. Data on the extent of life stages and body weights of the adults were obtained. Similar studies are in progress with *Bruchus* and *Stegobium*.

The other part of the work carried out under this programme relates to the application of food preferences of insect as a factor for pest control in a stored commodity. Spices are commonly infested by *S. paniceum* and the usual pests of whole cereal and pulses do not attack these materials. Survey of processed and un-processed dry foodstuffs were carried out with references to their normal pests. The repellence and attractance of different pests *S. oryza*, *T. castaneum*, *B. chinensis* and *S. paniceum*—to some processed foodstuffs were also studied during the period under report. In general, the seasoned materials were attacked by *S. paniceum*. It was noted that the preference of *S. oryza* and *T. castaneum* for the whole and milled materials respectively were counteracted and a marked degree of repellence was observed in the seasoned articles. Repellence tests were carried out with graded levels of cumin, pepper, turmeric and coriander in wheat semolina against *T. castaneum*. High degree of repellency was exhibited by turmeric, cumin and pepper at 500 and 2,500 p.p.m. concentrations. Coriander did not exert appreciable repellent action. Cumin, at 5 p.p.m. level, showed a little attractance for *T. castaneum*. Further studies are in progress to utilise the repellence factor of turmeric, to *T. castaneum* for its control under the storage conditions of wheat semolina in jute bags.

2.6 Storage studies on coffee

(In collaboration with Food Processing Division)

2.6.1 Monsooning of Cherry coffee: Studies were continued on the physical, chemical and biological aspects of the monsooned coffee. During the period under report, investigations were undertaken on the cherry (Robusta and Arabica) samples drawn during the progress of monsooning, at the curing works at Tellicherry, Mangalore and Calicut. Detailed analytical data were obtained on the progressive changes in moisture, microbial load, colour, density, total soluble solids, total nitrogen soluble nitrogen, caffeine, trigonelline, chlorogenic acid and sugars. The results showed that moisture progressively increased from 12 per cent in June to 16 per cent in September. The microbial load also increased progressively. Soluble solids and chlorogenic acid increased slightly while the colour got bleached; density, sugars and trigonelline recorded a decreasing trend in the course of monsooning. Susceptibility of the beans to the attack by *Araecerus fasciculatus*, increased progressively. Detailed histological studies and the experiments on microbial changes and enzymic activities are in progress. Also see under 5.1.1.

2.6.2 Storage of Plantation coffee: Pilot-scale experiments on the hermetic storage in prefabricated aluminium bin and polyethylene balloon structures were completed. The results of the trials demonstrated that green Plantation coffee could be stored in indoor metal structures in bulk. If the initial moisture content of the bean is kept below 10 per cent, factors like the moisture migration and condensation could be prevented during storage in bulk. Insect infestation was controlled in the hermetic condition due to depletion of oxygen and building up of high carbon dioxide tension. Mould growth and caking were also controlled by installing the structure in a shed, thus avoiding the development of high moisture pockets. Thermal insulation would be required for outdoor structures to offset the adverse effect of fluctuations in temperature.

Examinations of the colour, cup quality and the chemical analysis showed that the original quality of the Plantation coffee bean could be preserved well even in the high humid coastal areas. Further work is needed on ageing of coffee bean on storage in order to mellow down the fresh taste (harshness) as obtained in freshly cured coffee. Detailed report on this aspect is presented elsewhere. For further details, please see under 5.1.2.

2.6.3 Ballooning technique: Large-scale trials on the ballooning technique for storage of Plantation coffee in bag stacks under high humid conditions, were carried out. The efficacy of the technique in preventing damage by moisture, insect, mould and rodent, was further demonstrated. Commercial trials on the process by Coffee Board and Messrs. Volkart Bros., Messrs. Pierce Leslie & Co., and Messrs. Aspinwall & Co., with 25 ton lots in three places are in progress.

2.6.4 Disinfestation of monsooned coffee: The Coffee Board has accepted the recommendations on the application of the Durofume Process developed by the Institute for insect free storage of monsooned coffee. The production and export of monsooned coffee have increased considerably due to the introduction of the Durofume Process in all the coastal curing works for the last three years. The incidence of insect infestation and consequent claims by the importers of monsoon coffee abroad seem to have been eliminated.

Incubation tests, fumigant residue analysis and other quality control measures were carried out at this Institute on all the coffee stacks (3,000 tonnes) treated by the Durofume Process by a contract servicing firm.

2.7 Packaging vs stored grain insects

(In collaboration with Packaging and Containers Division)

Studies were continued on the screening of different types of cellophane, kraft papers, aluminium foils and their laminates for their relative susceptibility or resistance to insect penetration.

Detailed studies were carried out on the factors governing the physical and biological deteriorations of the test films under high temperature and humid conditions. Microbiological spoilage of the packaging films under storage conditions was studied. Histological and microbiological evidences in respect of the predisposing factors for the susceptibility of kraft paper-polyethylene laminates to insect penetration were obtained. It was observed that the physical strength properties also showed significant reduction with the increase of microbial count and hyphal ramification and insect punctures. Detailed report on the results of the experiments is under preparation.

3. Biochemistry and Nutrition

3.1 Investigations on rice and rice products

3.1.1 *Parboiling of rice:* The hot soaking method as developed at this Institute and described in the previous reports is under consideration by the Central Food Ministry for adoption on a country-wide scale.

3.1.2 *Curing of freshly harvested rice:* Treatment of freshly harvested paddy so as to obtain rice that cooks like old stored rice was reported earlier. In applying this treatment directly to milled rice, it was observed that rice was very sensitive to small changes of humidity and developed cracks when subjected to this treatment. It had, therefore, to be treated under controlled conditions of humidity and temperature. It was found that higher the temperature and humidity, shorter the time required for curing the rice. Necessary humidity could be built up by heating the rice in a closed chamber. Large batches were treated by heating in an electrical roaster.

3.1.3 *Experiments on characterization of different varieties of rice in relation to their culinary properties:* Experiments were conducted with 20 varieties of rice to determine any possible relation of their cooking qualities to their other characteristics. The characteristics determined were: (a) cooking time, (b) swelling ratio, (c) loss of solids in the gruel, (d) density, (e) moisture content, (f) grain thickness, (g) amount of solids leached out on shaking whole rice grain in water, (h) sieve analysis of flour on subjecting the rice grains to a fixed degree of stress, (i) iodine blue value and (j) amylose content.

A comparison of the values obtained for different characteristics with the pastiness of the different varieties of rice on cooking, indicated, in general, that greater the loss of solids on cooking, greater was the pastiness. None of the other characteristics showed any significant correlation with cooking quality.

3.1.4 *Utilization of rice bran:* Defatted rice bran contains about $\frac{1}{3}$ of its weight as nutrients in the form of starch and nitrogenous matter. These two fractions were separated by water extraction and the water extract concentrated. The PER of the starch fraction was 1.2. On the other hand, the soluble fraction, whether freeze dried or drum-dried, did not support rat growth or yeast fermentation. As this fraction contained more than 50 per cent of the nitrogen in the form of non-protein and considerable amounts of free reducing sugars, some of the amino acids notably lysine must have got bound and become unavailable during the heat-processing. This aspect is under study.

Analysis has revealed the presence of glutathione in rice bran. Attempts are being made to isolate it.

3.1.5 Studies on idli flour: There was no demonstrable difference in the growth promoting value of *idlis* from fermented or unfermented batters indicating that fermentation does not improve the nutritive value.

Technical help and advice were given to the Southern Railway, Madras, to produce a satisfactory *idli* flour for use by their catering establishment.

3.2 Investigations on dhal

3.2.1 Dhal flakes: Improvement in the cooking quality and cooking time of *dhal* flakes was reported previously. Consumer acceptability and suitability for use at high altitudes are being tried by the Defence Department. Methods to minimise flavour changes which flaking brings about are under study.

3.2.2 Treatment of *thur dhal* to improve its cooking quality and to reduce the cooking time: Of all the chemical treatments tried, treatment (spraying) with sodium phosphate has been found to be the best method from the point of view of improving the cooking time.

A quantitative method of determining the cooking quality of *dhal* has been standardised based on cooking *dhal* for a definite period, stirring it at a known speed and determining the solids passed through a standard sieve.

3.3 Refining of millets

Further to observations earlier recorded, a white, husk-free flour from *ragi* has been obtained by equilibrating the grain with moisture as would just wet the skin, toughen and loosen it from the grain and by passing the conditioned *ragi* through a wheat mill. Proximate analysis and nutritive value of this flour are under study.

By suitable modification of the process, *jowar*, wheat and *bajra* have been obtained without the skin.

3.4 New method of preparing calcium proteinate with the use of calcium hydroxide in sucrose solution

3.4.1 Preparation of water dispersible calcium caseinate: Conditions for the preparation of water dispersible calcium caseinate have been standardised based on the use of calcium hydroxide in sucrose as a reagent. Because it is possible to obtain calcium in solution in concentrations at least 50 times more than could be obtained in water solution, the use of sucrose solution of calcium hydroxide for the preparation of calcium caseinate has the advantage that the reaction takes place in a homogenous phase and is, therefore, fast. Further, there is considerable saving of

heat energy in drying the product because of the small volume of the calcium reagent used. Application for a patent to cover this method of preparation has been filed.

The drum-dried preparation has acceptable organoleptic and storage qualities and disperses easily in water, giving a pH of 5.8 in solution. It has a PER of 2.2. Its efficiency for treatment of protein malnutrition has been established by successfully treating 9 malnourished children.

All the calcium is in the bound form as shown by the absence of tests for ionic calcium. A remarkable observation made was that casein is able to withdraw calcium from its combination from ethylene diamine tetraacetic acid (EDTA) calcium chelate.

3.4.2 Processing of fish proteins: The use, now established, of calcium hydroxide in sucrose for the preparation of water dispersible calcium caseinate was extended to fish protein, mutton and groundnut protein. Although completely water dispersible products were not obtained in these cases even after short-term, weak pre-digestion with papain the calcium treated proteinates, after drum drying, were free from odour in all the cases and showed some exceptionally desirable features. For example, preparations from fresh water fish (*Barbus carnaticus*) muscle protein had the following properties; a pleasing silky sheen, soft to the feel, free flowing, light (low bulk density) and a capacity to blend easily with foods (raw or cooked) without affecting their natural taste or smell, because the sample itself had a bland taste and no smell. These qualities were found to be retained by the product packed loose and stored at 37°C for a period of over 9 months.

The calcium treated preparation of fish had a protein content of 80 per cent with a PER of 2.9. Preliminary trials have shown that cooked fish fillets similarly processed give a comparable product. One batch had a PER of 3.2.

Trials have shown that the product obtained by drum-drying on ammoniacal dispersion of fish muscle without calcium is not as good as the one with calcium. Thus, calcium seems to be an essential requirement in this process. Its function and the form in which it is present in the final product are under study.

3.5 Chronic toxicity tests on rats receiving vanaspati coloured with turmeric extract and ratanjot, in comparison with plain vanaspati

The use of turmeric extract and *ratanjot* has been recommended for colourization of *vanaspati*. Before adopting either of these two colours, it was necessary to show that neither of them was toxic. For this study, weanling rats were fed *vanaspati* containing *ratanjot* or turmeric extract at the stipulated levels in both adequate and poor rice diets. Both by growth studies and histopathological examination of the tissues

(liver, aorta and kidney), it was shown that prolonged ingestion of *vanaspati* containing turmeric extract (0.04 per cent) or *ratanjot* (0.4 per cent) did not produce any toxic symptoms in the rat.

3.6 Effect of feeding turmeric extract on cholesterol levels

Feeding of turmeric extract has been shown in preliminary experiments to bring down cholesterol levels in rats previously rendered hypercholesterolemic.

3.7 Diet and diabetes

3.7.1 Effect of protein: The hypoglycemic effects of protein in the tolerance test have been confirmed in over 70 per cent of the 24 diabetic subjects tested. The availability of clinical material has now become possible, because of a diabetic out-patient ward recently started at a local hospital at our request. Arrangements are in progress to have in-patient ward facilities to intensify these investigations.

3.7.2 Effect of protein hydrolysate: Papain and trypsin hydrolysate of casein did not have any more hypoglycemic effect than the intact protein in oral and intravenous tolerance tests in the normal subject.

3.7.3 Changes in blood amino nitrogen and serum inorganic phosphate following ingestion of glucose with and without protein: In understanding the beneficial effects of protein in bringing down hyperglycemia in tolerance tests, studies on parallel changes in plasma amino nitrogen and serum inorganic phosphate have been initiated. An interesting preliminary observation made is that, following the ingestion of protein, there is a significant fall in serum inorganic phosphate from the fasting level.

3.7.4 Relationship between blood sugar and urine sugar: Statistical examination of the data accumulated over the years by us with a single diabetic subject has shown that the total sugar voided in urine in three hours (test period) and the sum of the blood sugar in excess of 200 mg. per cent (renal threshold in this subject) is remarkably linear. This was true whether the glucose was ingested alone or after insulin or ingested with another food material or whether the carbohydrate ingested was corn starch or rice. From these data, the regression equation connecting urine sugar voided in 3 hours (Y) with the sum of excess over 200 mg. per cent blood sugar (X) works out as follows:

(A) for glucose: $Y=0.33+0.0318 X$

(B) for glucose with prior administration of insulin with or without addition of food components severally:

$$Y=-0.04+0.0314 X \text{ and}$$

(C) for starch and cereals: $Y=1.59+0.0229 X$

3.7.5 Effect of Mn^{++} : Rubenstein *et al.* (*Nature*, 1962, **194**, 188) have reported recently the effect of Mn^{++} in bringing down substantially fasting blood sugar from its highly elevated level in a diabetic subject. They did not get this beneficial effect in 7 other diabetic subjects. We repeated this experiment with Mn^{++} on a diabetic subject, but the hypoglycemic effect was not noticed.

3.7.6 Alloxan diabetes in rats and effect of protein: Rats reared on otherwise adequate diets but deficient in both sulfur amino acid and sodium showed a tendency to resist alloxan diabetes.

3.8 Vegetable protein hydrolysates

Employing optimal conditions of particle size (60-80 mesh), temperature (60°) and pH (6.5-6.8), 3-5 kg. of groundnut protein isolate has been subjected to enzymic hydrolysis (papain) and a concentrate free from undigested protein containing 45-50 per cent solids was first obtained and then dried by spray-drying or vacuum shelf drying. By adding 2-3 per cent citric acid and by further incorporation of 15-20 per cent sucrose and 10 per cent dextri-maltose, acceptable products have been prepared. Blends of groundnut protein hydrolysates with soya and safflower proteins have been tried with a view to balancing the amino acid composition.

3.9 Amino acid composition of tender and mature field bean

It was previously reported that the influence of protein from field bean on the glucose tolerance test varied with the stage of maturity of the bean. It was, therefore, of interest to have information on the amino acid composition of tender and mature field bean proteins. This was determined by microbiological assay on the whole seed, alcohol extract (free amino acids) and on the residue (true protein). Tryptophan and proline were not estimated.

There was no significant difference in the free or protein bound amino acid make up of tender and mature field beans. The composition followed the pattern for legume proteins in general and alike, methionine was the major limiting amino acid.

3.10 Influence of dietary protein and sulfadruugs on vitamin C status of the rat

3.10.1 Effect of dietary lactose: In further studies with lactose containing diets, it was confirmed that, at 10 per cent level, it served to counteract the adverse effect of 2 per cent sulfaguanidine on vitamin C excretion in rats receiving 10 per cent casein diet. This was reversed when the dietary level of the sulfadruug was raised to 4 per cent. At 30 per cent protein level, which by itself largely nullifies the depressant effect of 2 per cent sulfadruug, the supplementation of 10 per cent lactose did not augment the urinary excretion of the vitamin.

3.10.2 Effect of protein quality and amino acid supplements: In rats fed diets containing 10 and 20 per cent gelatin as the sole source of protein, both the urinary excretion and liver levels of the vitamin were very low. Supplementation of the 10 per cent gelatin diet with the deficient amino acids to make it equivalent to 10 per cent casein, restored these levels to a par with those obtained with 10 per cent casein diets.

3.10.3 Counteraction of sulfadrag effects by protein: The depressant effects of sulfadrag on urinary and liver levels of the vitamin with low protein diets was confirmed by including sulfaguanidine and sulfasuccidine at 2-2.5 and 4 per cent levels in low protein diets. These effects were nullified when the protein content of the diet was raised to 50 per cent.

3.10.4 Observations on fasted rats: As contrasted with extremely small amounts of urinary ascorbic acid excreted by rats fed a protein-free diet; rats which were totally fasted, excreted the vitamin in urine in amounts comparable with those receiving a 10 per cent casein diet. The liver levels of the vitamin were also on par with those of the latter.

3.11 Biochemical studies on the germination of Sesbania seeds

In a concluding study on the polysaccharides of the inner seed coat of sesbania seeds, it was shown that glucomannan forms only a minor portion of the carbohydrates (less than 2 per cent) in the coat. There was no uptake of the galactomannan when fed with the irrigating fluid to the germinating seedlings. Sequential studies on the release of sugars from the coat during germination and *in vitro* experiments with extracts of the seed coat revealed the presence of a galactomannan splitting enzyme in the coat, thus confirming that the galactomannan was the main source of sugar for the sucrose synthesis and other observed changes.

3.12 Poppy seed globulins

By slow dialysis of a 5 per cent sodium chloride extracts of defatted poppy cake, a crystalline globulin, consisting mainly of hexagonal platelets (microscopic), was obtained. Homogeneity studies, based on differential solubility and paper electrophoresis have shown the presence of four components in the preparation.

3.13 Investigations on heated fats

Poor growth, liver damage and ultimate death in rats due to the ingestion of heat oxidized fats has been studied by a number of workers (*Nutr. Reviews*, 1960, **18**, 19). Such nutritionally hazardous fats are found in many of our food preparations. Survey of literature shows that absorption pattern and absorption mechanism of such fats are not well known. These aspects have been taken up for study using the rat as the experimental animal.

3.14 I.C.M.R. scheme on nutritive value of foodstuffs

The scope of the work has been mentioned in the previous report 23 foodstuffs have been analysed during the period involving a total analyses of 420 consisting of the usual constituents as listed in the Health Bulletin. Thus 45 gaps in the analytical values of these foodstuffs have been filled.

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3.15 Changes in liver and subcellular fractions under stress conditions

3.15.1 Carbon tetrachloride liver injury: In carbon tetrachloride (CCl_4) administered rats, the increase in liver lipids is mostly in the fatty acids of acetone soluble lipid. The phospholipid content of the livers is significantly low and a slight increase is observed in hepatic cholesterol. Experiments with liver slices using acetate- C^{14} show that the lipid fractions are slightly affected during the early stages of toxicity. However, the labelling of these fractions is greatly diminished by 24 hours. Rate of oxidation of unlabelled caprylate by liver homogenates show very little decrease at the end of 3 hours and the fatty acid oxidation is considerably impaired by 24 hours. CCl_4 poisoning also results in considerable decreases in plasma albumin and in lipids of plasma proteins, by 3 hours after administration. These studies suggest that the lipid accumulation in this stress condition might be due primarily to an impairment of transport from liver in the early stages and to decreased oxidation also in the later stages.

Heavy mitochondria show no changes in succinoxidase, succinic dehydrogenase and cytochrome C activities in livers of rats administered CCl_4 showing that these enzymes serve as an index of severity of mitochondrial damage.

The microsomal yield from livers of CCl_4 administered rats is considerably decreased by 18 hours. The destruction is much less during the first 3 hours period.

3.15.2 Studies on thyrotoxicosis: Glucose-6-phosphatase activity of microsomes showed an increase in thyrotoxic rat livers indicating a drain on the high energy phosphate. The glucose-6-phosphate dehydrogenase activity of liver homogenate is also more in this stress condition suggesting the operation of oxidative metabolism of carbohydrate in preference to the normal glycolytic route. Vitamin B_{12} supplementation to the diet did not show any beneficial effects.

The ribonuclease activity of the homogenate is also more in this stress condition and vitamin B_{12} brings about some lowering in the activity of this enzyme.

3.16 Characterization of subcellular components

3.16.1 Studies on microsomes: Potassium ions have been shown to activate the latent ribonuclease activity of microsomes from livers of normal rats.

3.16.2 Electrophoretic separation of soluble proteins: An improved electrophoretic method for a comparative study of the supernatant proteins of various organs of rat has been developed. Interesting differences have been observed in the electrophoretic patterns of heavy and light mitochondria from perfused livers.

A new band, possibly of protein nature and fluorescing red in ultraviolet, has been observed.

3.16.3 Studies on transaminases: A method for the assay of hepatic glutamic-pyruvic and glutamic-oxaloacetic transaminases has been standardised.

3.17 Catalase synthesis and respiration of *Saccharomyces cerevisiae*

Cysteine inhibits catalase formation and respiration in *Saccharomyces cerevisiae*. Iron salts have to a certain extent beneficial effects against these inhibitions. Other amino acids do not inhibit catalase induction. Homocysteine and glutathione are slightly inhibitory to catalase induction as well as respiration. Malonate did not interfere with yeast respiration, but inhibited catalase synthesis, while succinate reverses these effects to a certain extent.

3.18 In vitro synthesis of serum albumin

Liver slices incorporate less activity *in vitro*, from glycine-2-C¹⁴ into albumin fraction in vitamin B₁₂ deficiency. There is no impairment of albumin synthesis in folic acid deficiency. In CCl₄ injected rats, *in vitro* synthesis of serum albumin is significantly reduced even before the mitochondria are damaged morphologically. Vitamin B₁₂ has no protective effect against these changes.

3.19 Influence of protein and fat on liver levels of some cofactors and enzymes

Preliminary results show that D-amino acid oxidase activity of liver homogenate and choline oxidase activity of mitochondria are low in groundnut protein fed rats in comparison with casein at isoprotein level of 10 per cent. Supplementation of the vegetable protein with lysine and methionine indicated beneficial effects in restoring these enzyme levels to normal and in increasing the glutathione levels of liver.

In another set of experiments, the biochemical changes in liver of rats fed diets containing casein or groundnut protein (9 and 18 per cent) and at two levels of fat (5 and 30 per cent) have been investigated. At

9 per cent protein level, nitrogen and choline oxidase contents of livers are more in rats fed casein in comparison with groundnut protein. These differences are negligible at higher protein intake (18 per cent). Choline oxidase activity of homogenate is higher in casein fed animals given low protein (9 per cent) and high fat (30 per cent).

3.20 Choline metabolism

3.20.1 Choline biosynthesis in rat liver: As compared to folic acid supplemented controls, liver slices from folic acid deficient rats incorporate less activity into phosphatidyl choline from $C^{14}H_3$ -methionine. *In vitro* addition of tetrahydrofolic acid does not restore this lowered incorporation. Addition of serine and formate does not dilute radioactivity incorporated into methyl groups of phosphatidyl choline. These results support the recent hypothesis that the methyl portion of phosphatidyl choline may be formed by transmethylation.

In vitro and *in vivo* kinetic experiments using serine-3- C^{14} and $C^{14}H_3$ -methionine show that phosphatidyl choline is formed earlier than free choline in the rat liver.

3.20.2 Metabolism of choline in *Neurospora crassa*: The choline sparing effect of methionine in *Neurospora crassa* (cholineless) has been further examined. Studies with $C^{14}H_3$ -methionine indicate that this effect is not due to utilization of methyl groups of methionine for choline biosynthesis.

3.21 Conversion of tetrahydrofolic acid to citrovorum factor in *Escherichia coli*— B_{12} + methionine auxotroph

Serine acts as a better one carbon donor than formate in the conversion of tetrahydrofolic acid (THFA) to citrovorum factor (CF). Vitamin B_{12} lowers the conversion when serine is the one carbon donor and enhances it when formate is the donor. Increasing concentrations of serine are able to reverse the suppression by vitamin B_{12} . Homocysteine considerably brings down CF synthesis from THFA and serine in presence of vitamin B_{12} but not in its absence. Methionine does not affect this conversion with or without vitamin B_{12} . These results indicate that vitamin B_{12} dependent homocysteine to methionine conversion considerably influences CF formation.

3.22 Protein and nucleic acid biosynthesis in *Escherichia coli* vitamin B_{12} /methionine auxotroph

3.22.1 Alkaline phosphatase formation: A possibility that formation of alkaline phosphatase in *E. coli* mutant may be due to a selection of mutants possessing high alkaline phosphatase protein has been ruled out, since there is no difference observable in viable counts of cultures plated

on high and low phosphate media. Alkaline phosphatase could be synthesised even when cell division is inhibited by penicillin. Inorganic phosphate suppresses further increase in alkaline phosphatase activity during growth, but does not induce degradation of the phosphatase already present.

3.22.2 *Ribonucleic acid synthesis during phosphate starvation:* Using glycine-2-C¹⁴ as the precursor of ribonucleic acid (RNA), it has been demonstrated that there is a turnover of ribonucleic acid in *E. coli* mutant during phosphate starvation, although there is no net increase in the RNA content.

3.22.3 *Non-participation of vitamin B₁₂ in protein synthesis:* Vitamin B₁₂ antagonists do not influence the incorporation of glycine-2-C¹⁴ into proteins of the *E. coli* mutant. This substantiates the earlier evidence obtained in this laboratory that vitamin B₁₂ has no direct role in the mechanism of protein synthesis at least in the *E. coli* mutant.

4. Dietetics

Investigations on the following problems were continued during the year under review: low-cost balanced foods suitable for weaned infants and children; processed protein foods based on oil seed meals, pulse flours, skim milk powder and fish flour; metabolism of nitrogen, calcium and phosphorus in children on different diets; clinical studies; and design and demonstration of improved food compositions and recipes suitable for different economic levels.

4.1 Studies on dried milk substitutes of vegetable origin suitable for infants and young children

(In collaboration with Meat and Fish Technology Division)

The results of studies on the overall nutritive value of dried milk substitutes based on blends of groundnut and soya bean have been presented in the last annual report. Further studies were continued on the supplementary value of the different products to poor Indian rice diet using albino rats.

The results showed that incorporation of milks reconstituted from vegetable milk powders from a 2:1 blend of soya bean and groundnut or a 4:1 blend of vegetable and modified cow's milk powders in a poor rice diet so as to provide about 4.5 per cent extra protein resulted in a highly significant improvement in the growth promoting value of the diet.

No significant differences were observed in the mean haemoglobin and R.B.C. count of blood, or the mean moisture, fat and protein contents of the livers and carcasses of rats receiving the different milk supplements. The mean R.B.C. count and haemoglobin of the blood and the mean protein content of the livers and carcasses of rats receiving the milk supplements were, however, significantly higher than the values obtained for rats fed on the basal rice diet.

4.2 Spray-dried protein foods based on groundnut protein isolate and skim milk powder suitable for feeding weaned infants and children

(In collaboration with Processing Division)

Details of the preparation and chemical composition of spray dried protein foods based on groundnut protein isolate and skim milk powder suitable for feeding weaned infants and children were given in the last

annual report. Further investigations were carried out on the shelf-life and nutritive value of these products.

4.2.1 Nutritive value and shelf-life of infant food formula: The protein efficiency ratios (PER) of the infant food formula were determined at 10, 15, 20 and 25 per cent levels of protein intake.

The results showed that the PER of the infant food formula (2.33) was significantly less than that of milk food (3.22) at 10 per cent level, but no significant differences were observed in the PER of the two foods at 15, 20 and 25 per cent levels, at which such foods are normally used for infant feeding.

Storage studies on the shelf-life of infant food formula showed that the product was organoleptically acceptable when evaluated at the end of 7 months' storage at room temperature and at 37°C. The losses of vitamin A in samples stored for 7 months at room temperature and at 37°C were about 23 per cent and 30 per cent respectively and of vitamin C, about 20 per cent and 33 per cent respectively. The solubility of the product in water at 60°C ranged from 88 to 90 per cent and did not change appreciably after storage. There was only a slight increase in the peroxide and T.B.A. values of the fat in the samples stored at room temperature and at 37°C for 7 months.

4.2.2 Nutritive value and shelf-life of spray-dried protein food: The PER of the above food was determined at 10, 15 and 20 per cent levels of protein intake. The data showed that at 15 and 20 per cent levels (at which the food would be used for the treatment of *Kwashiorkor*) there were no significant differences in the PER of the food (2.33 and 1.76) and skim milk powder (2.49 and 1.84). At 10 per cent level, however, the PER of the food (2.33) was significantly less than that of skim milk powder (3.32).

The supplementary value of the food to poor rice diet at 10 per cent level as compared to skim milk powder was determined by growth experiments using albino rats.

The results showed that the protein food at 10 per cent level (at which the food is likely to be used as a supplement to the diet of weaned children) brought about a marked improvement in the nutritive value of the diet, comparable to that obtained with skim milk powder, as judged by the growth of albino rats.

No significant differences were observed in the R.B.C. count and haemoglobin content of blood or in the mean moisture, protein and fat contents of the liver and carcass of rats receiving the supplements of spray-dried protein food or skim milk powder. The mean R.B.C. count and haemoglobin of blood and the protein content of liver and carcass of rats receiving the supplements were significantly higher than those of rats on the control rice diet.

Studies on the shelf-life of spray-dried protein food showed that the product kept well for a period of 7 months when stored at room

temperature (25—29°C) or 37°C. The losses of vitamins A and C in samples stored at 37°C for 7 months were 34 and 33 per cent respectively.

4.3 Nutritive value of a high protein biscuit containing groundnut protein isolate and casein, fortified with calcium salts and vitamins

(In collaboration with Processing Division)

Biscuit is a popular item in the diet of weaned infants and young children. Investigations were, therefore, carried out on the preparation and nutritive value of a biscuit-like product based on groundnut protein isolate and casein.

The biscuit was prepared from a 4:1 blend of groundnut protein isolate and casein and was adequately fortified with vitamins and minerals. It was baked at 380°F for a period of 5 minutes. The losses of vitamin A and thiamine as a result of baking were 11.0 and 11.3 per cent respectively. Losses of riboflavin and niacin during baking were not appreciable.

4.3.1 Shelf-life: The biscuits were organoleptically acceptable after storage for 6 months at 37°C, the losses of vitamin A and thiamine during the period being 35 and 14 per cent respectively.

4.3.2 Nutritive value of the proteins: The PER of the biscuit was determined at 10 per cent level of protein intake by the rat growth method. The data showed that there were no significant differences in the PER at 10 per cent level of intake of the biscuit (1.97) or the unbaked biscuit mix (2.26). The PER of the biscuit (1.97) was, however, significantly less than that of casein (2.55).

4.3.3 Supplementary value to a poor rice diet: The supplementary value of the high protein biscuit at 10 per cent level to a poor Indian rice diet was determined by the rat growth method. The results showed that the biscuit at 10 per cent level of supplementation brought about a marked improvement in the nutritive value of the diet comparing well with that obtained with skim milk powder. The mean protein contents of the livers and carcasses of rats fed on diets supplemented with the biscuit or skim milk powder were significantly higher than those of rats fed on the control rice diet.

4.4 Studies on processed protein foods based on oilseed meals, pulse flours and skim milk powder

Studies on the nutritive value of processed protein foods based on oil seed meals suitable for supplementing the diets of children and other vulnerable groups of the population were continued.

4.4.1 Studies on the nutritive value of groundnut flour and blends of groundnut flour and skim milk powder fortified with essential vitamins and minerals: Groundnut flour in combination with other protein-rich materials such as pulses and skim milk powder has been used by some workers for the treatment of protein malnutrition in children and also as a supplement to the diets of young children. While the proteins of groundnut flour possess a lower nutritive value than those of skim milk powder, the proteins of blends of groundnut flour and skim milk powder can be moderately high in nutritive value and may prove suitable for the treatment of protein malnutrition in children.

4.4.2 Shelf-life: Edible low fat groundnut flour and blends of groundnut flour and skim milk powder (in the ratio of 9:1 and 4:1 respectively) fortified with calcium salts and vitamins A and D, thiamine and riboflavin, were prepared. The different products kept well at 37°C in hermetically sealed containers for a period of 8 months. The losses of vitamin A, thiamine and riboflavin in the different products during the storage period were 21-23 per cent, 15-19 per cent and 8-12 per cent respectively.

4.4.3 Nutritive value of the proteins: The PER of groundnut flour and a 4:1 blend of groundnut flour and skim milk powder were determined at 10, 15 and 20 per cent levels of protein intake by the rat growth method. The PER of the 4:1 blend of groundnut flour and skim milk powder at 10 per cent level of protein intake (2.36) was significantly higher than that of the proteins of groundnut flour (1.84) but lower than that of milk proteins (3.04). At higher levels (15 and 20 per cent), there were no significant differences in the PER of groundnut flour, skim milk powder, or a 4:1 blend of groundnut flour and skim milk powder, the values ranging from 1.98 to 2.32 at 15 per cent level and 1.78 to 1.97 at 20 per cent level. The gain in body weight of rats on diets containing 15 or 20 per cent protein from groundnut flour or 4:1 blend of groundnut flour and skim milk powder were nearly equal to those obtained with diets containing 15 or 20 per cent milk proteins respectively.

4.4.4 Supplementary value to poor rice diet: The supplementary value of fortified groundnut flour and blends of groundnut flour and skim milk powder (in the ratio of 9:1 and 4:1 respectively) to poor rice diet was determined by growth experiments using albino rats. The results indicated that incorporation of the above protein foods to provide 5.0 per cent extra protein in the diet resulted in highly significant increases ($P < 0.001$) in the growth rate of rats. The diet supplemented with a blend of groundnut flour and skim milk powder promoted slightly better growth than that with groundnut flour alone. The mean fat content (4.2 per cent) of the livers of rats fed on the control rice diet was higher and the mean protein content (17.1 per cent) lower than the corresponding values (3.0—3.7 per cent and 17.9—19.8 per cent respectively) for the rats receiving the protein supplements. The livers of rats on the control rice diet

showed a mild degree of parenchymal damage of the protein deficiency type. On the other hand, the livers of rats receiving supplements of groundnut flour, skim milk powder or their blends were quite normal, indicating that groundnut flour as such or blends of groundnut flour with skim milk powder (in the proportion of 9:1 or 4:1) were as effective as skim milk powder in correcting the protein deficiency in the diet and in preventing liver damage. There were no significant differences in the retention of protein per 100 g. increase in body weight of rats receiving the protein supplements, indicating thereby that the increase in body weight of rats was followed by a corresponding increase in the body protein content.

4.4.5 *Supplementary value to poor maize-tapioca diet:* The incidence of protein malnutrition is particularly high in regions where diets based on maize and tapioca are consumed, since such diets contain low levels (5-6 per cent) of protein of poor quality. Studies were, therefore, carried out on the supplementary value of fortified groundnut flour and its blend with skim milk powder to a poor diet based on a 1:2 blend of maize and tapioca. The different protein foods provided 15 per cent extra protein. The results showed that the control maize-tapioca diet promoted very little growth (0.63 g./wk) in albino rats. Supplementation of the diet with groundnut flour, skim milk powder or their blends resulted in increased growth rate of rats. No significant differences were observed in the mean weekly growth rate of rats (17.5—19.1 g.) receiving the different protein supplements. The mean fat content of the livers of rats fed on the maize-tapioca diet (5.5 per cent) was significantly higher ($P < 0.001$) than those of rats (3.5—3.8 per cent) receiving the protein supplements.

Histological examination of the livers of rats fed on the maize-tapioca diet showed moderate degree of parenchymal damage of the protein deficiency type and severe periportal fatty infiltration. On the other hand, the livers of animals receiving the protein supplements were quite normal.

There were no significant differences in the mean retention of protein per 100 g. increase in body weight of rats receiving the different protein supplements. On the other hand, the rats fed on the maize-tapioca diet for 8 weeks lost some body proteins. The results obtained clearly indicated that fortified groundnut flour or its blends with skim milk powder could be used as effective supplements for making up the protein deficiencies in poor maize-tapioca diets.

4.5 Relative efficacy of blends of groundnut protein isolate and skim milk powder in the regeneration of haemoglobin and plasma proteins in protein depleted albino rats

The relative efficacy of groundnut protein isolate, protein blend II (a mixture of groundnut protein isolate 52 parts and skim milk powder

48 parts) and of protein blend III (a mixture of groundnut protein isolate, 2 parts and skim milk powder, 1 part) for the regeneration of haemoglobin and plasma proteins as compared with that of skim milk powder was studied using protein depleted albino rats. The repletion diets contained 20 per cent protein.

The mean increases in circulating haemoglobin, plasma proteins and albumin in rats fed on groundnut protein isolate were significantly lower than that observed in rats fed on skim milk powder or blends of groundnut protein isolate and skim milk powder (protein blends II and III). There were, however, no significant differences in the mean increases of circulating haemoglobin, plasma proteins and albumin in rats fed on diets containing skim milk powder or blends of groundnut protein and skim milk powder. The results indicate that groundnut protein, by itself, was slightly less effective, while blends of groundnut protein isolate and skim milk powder were almost as effective as skim milk powder in the regeneration of serum proteins and haemoglobin in protein depleted rats.

4.6 Nutritive value of fortified coconut meal and protein foods based on blends of coconut meal, groundnut flour and Bengalgram flour

The overall nutritive value of coconut meal and protein foods I and II based on blends (2:1:1 or 2:1:2) of groundnut flour, Bengalgram flour and coconut meal (all fortified with calcium salts and vitamins) as compared to skim milk powder, was determined by growth experiments on albino rats over a period of 8 weeks. The different foods provided 16 per cent protein in an otherwise adequate diet.

The results showed that diets containing 16 per cent protein from coconut meal or the protein foods promoted good growth in albino rats. The mean weekly growth rate of rats on the diets containing coconut meal (13.7 g.) was, however, significantly less than that observed on the protein foods (16.4 and 14.8 g.) or skim milk powder (17.7 g.). There were no significant differences in the blood, liver or carcass composition of rats in the different groups. No significant difference was observed in the retention of protein per 100 g. increase in weight showing that the increase in weight of rats on the different diets was accompanied by a corresponding increase in the body protein content also.

4.7 Studies on the nutritive value of edible fish flour and a protein food based on fish flour

(In collaboration with Meat and Fish Technology Division)

Studies were carried out to assess the nutritive value of edible fish flour from oil sardine and a protein food based on a 2:1:1 blend of groundnut flour, Bengalgram flour and fish flour.

4.7.1 Chemical composition and shelf-life: The results of studies on the preparation of edible fish flour from oil sardine were presented in the last report. The fish flour thus obtained was almost odourless.

A protein food consisting of a 2:1:1 blend of groundnut flour, Bengalgram flour and fish flour fortified with vitamins and minerals was prepared. The protein food contained 51.6 per cent protein ($N \times 6.25$) and provided substantial amounts of calcium (1.8 per cent) and different vitamins.

The protein food kept well at 37°C in sealed containers for a period of 8 months. The losses in vitamin A and thiamine during the period of storage were about 25 per cent and 14 per cent respectively.

4.7.2 Supplementary value of the proteins of fish flour to those of groundnut flour and the protein efficiency ratio of the protein food containing fish flour: The supplementary value of the proteins of fish flour to those of groundnut flour and the PER of the protein food containing fish flour were determined by the rat growth method.

The results showed that the PER of the fish flour (2.92) was nearly of the same order as that of milk proteins (3.04) at 10 per cent level of protein intake. The PER of blends of groundnut and fish flours providing proteins in the ratio of 3:1 and 1:1 were 2.08 and 2.48 respectively, as compared with a value of 1.50 obtained for groundnut proteins, indicating thereby that the proteins of fish flour could supplement those of groundnut flour to a significant extent. The PER (2.56) of the protein food (based on a 2:1:1 blend of groundnut flour, Bengalgram flour and fish flour) was significantly higher than that of Indian multi-purpose food.

4.7.3 Supplementary value to poor rice diet: The supplementary value of fish flour and the protein food containing fish flour to poor rice diet was determined by growth studies using albino rats. The results indicated that fish flour or the protein food when incorporated to provide 5 per cent extra protein in the diet, brought about a highly significant ($P < 0.001$) increase in the growth of rats. There were no significant differences in the mean weekly growth rates of rats receiving the supplemented diets. The mean fat content (3.81) of the livers of rats fed on the control rice diet was higher and the mean protein content (16.7 per cent) lower than the corresponding values (3.0—3.2 per cent and 18.4—18.5 per cent) for the rats receiving the protein supplements. The livers of animals fed on the rice diet showed mild to moderate degree of parenchymal damage of the protein deficiency type, while those of rats receiving the protein supplements were quite normal.

No significant differences were observed in the mean retention of protein per 100 g. increase in body weight of rats fed on the rice diet or the same supplemented with the protein food.

4.7.4 Supplementary value to poor Indian diets based on different cereals and millets: The supplementary value of fortified fish flour at 3 per cent level (providing about 2.5 per cent extra protein) to poor Indian

diets based on different cereals was studied as compared to skim milk powder at 7 per cent level.

The results showed that supplementation of poor Indian diets based on rice, wheat, *jowar* and *ragi* with fortified fish flour at 3 per cent level or skim milk powder at 7 per cent level to provide 2.5 per cent extra protein and about 100 mg. per cent extra calcium, brought about highly significant increases in the growth rate of rats, fish flour, proving slightly superior to skim milk powder in this respect.

There were no significant differences in the mean fat contents of the livers of rats fed on the different diets. The mean protein contents (18.30—19.05 per cent) of livers of rats receiving supplements of fish flour or skim milk powder were significantly greater than those (16.69—18.08 per cent) of the livers of control groups of rats receiving the cereal diets.

4.7.5 *Supplementary value to a maize-tapioca diet:* Investigations were undertaken to study the supplementary value of fish flour and protein food containing fish flour to a low protein diet based on a blend of maize and tapioca.

The results showed that the maize-tapioca diet promoted very little growth (1.8 g/wk.) in albino rats. Supplementation of the diet with fish flour, protein food or skim milk powder so as to provide 10 per cent extra protein in the diet resulted in highly significant ($P < 0.001$) increases in the growth of rats.

No significant differences were observed in the mean weekly growth rate of rats (19.3—19.7 g./wk) receiving the different protein supplements. The mean fat content (5.02 per cent) of the livers of rats fed on the control maize-tapioca diet was significantly ($P < 0.001$) higher than those of rats receiving the protein supplements. The livers of rats fed on the control maize-tapioca diet showed moderate degree of parenchymal damage of the protein deficiency type and severe periportal fatty infiltration. On the other hand, the livers of animals receiving the different foods were quite normal indicating that, when providing 10 per cent extra protein to the diet, the protein food containing fish flour was as effective as fish flour or skim milk powder in correcting the protein deficiency in the maize-tapioca diet and in preventing liver damage. There were no significant differences in the mean retentions of protein per 100 g. increase in body weight of rats receiving the different protein supplements indicating thereby that the increase in body weight of the rats was accompanied by a corresponding increase in the body protein content.

4.7.6 *Relative value of the protein food containing fish flour as compared with skim milk powder in meeting the protein requirements of protein depleted rats:* Rehabilitation of protein depleted rats by feeding for 21 days on diets containing 20 per cent protein from a protein food containing fish flour or from skim milk powder restored the R.B.C. count

and haemoglobin content of blood, serum protein level and xanthine oxidase activity of the liver to normal levels.

The mean gains in body weight per g. of protein intake were 1.94 and 2.08 g. and the mean gains in body weight per gram of protein retained were 6.05 and 6.15 g. respectively. The mean protein retentions expressed as percentage of intakes were 32.0 and 33.9 respectively on the two diets. No significant differences were observed in any of the above constituents between the two groups of rats fed on diets containing the protein food or skim milk powder.

4.8 Metabolism of nitrogen, calcium and phosphorus in children

4.8.1 *Metabolism of nitrogen, calcium and phosphorus, digestibility co-efficient, biological value and net protein utilization of poor Indian diets based on rice or a mixture of rice and maize:* The effect of replacing 25 per cent 50 per cent or all of the rice in a poor Indian diet by maize on nitrogen, calcium and phosphorus metabolism was studied in eight boys aged 9-10 years.

The daily intake of N on the different diets varied from 6.61 to 8.66 g. (about 41 to 54 g. of protein) and increased with the amount of maize in the diet. The mean daily N retentions were 2.04, 1.87, 1.35 and 0.99 g. for the rice diet and the diets in which 25 per cent, 50 per cent or all of the rice was replaced by maize. The apparent and true digestibility co-efficients were 77.1 and 88.2, 74.1 and 84.2, 63.5 and 73.3 and 54.0 and 62.5 respectively, while the biological values of the proteins were 71.5, 66.2, 62.0 and 57.6 respectively. The NPU (Op) values for the different diets were as follows: rice diet, 63.1; 25 per cent maize diet, 55.6; 50 per cent maize diet, 45.3 and maize diet, 35.9. The net dietary protein calories per cent (NDP-cal. per cent) of the different diets were 6.12, 5.87, 5.19 and 4.81 respectively. The net available proteins from the rice diet (26.1 g.) and 25 per cent maize diet (25.0 g.) met the requirements of 25.1 g. of FAO reference protein. On the other hand, the net available proteins from the 50 per cent maize diet (21.4 g.) and maize diet (19.4 g.) were less than the requirements.

The mean daily calcium intakes were 362, 366, 373 and 382 mg. respectively on the rice diet and the diets in which 25 per cent, 50 per cent or all of the rice was replaced by maize. The retentions were 149, 110, 89 and 67 mg. The retention of Ca decreased with the increase in the amount of maize in the diet. The mean daily phosphorus intakes were 697, 860, 1093 and 1389 mg. on the rice diet and the diets in which 25 per cent, 50 per cent or all of the rice was replaced by maize. The retentions were 153, 192, 250 and 341 mg. respectively.

It could be concluded from the above results that replacement of rice in the diet by maize to the extent of 25 per cent would not adversely affect the retention of nitrogen and calcium in children.

4.8.2 Metabolism of nitrogen, calcium and phosphorus, digestibility co-efficient, biological value and net protein utilization of poor rice diet supplemented with groundnut flour, groundnut protein isolate or skim milk powder: The metabolism of nitrogen, calcium and phosphorus was studied in eight girls aged 8-9 years fed on a poor rice diet and the same diet supplemented with fortified groundnut flour (GNF), groundnut protein isolate (GPI) or skim milk powder (SMP) to provide about 20 g. protein, 745 mg. of calcium and 568 mg. phosphorus and adequate amounts of vitamins A, D and B complex.

The mean daily intakes of N on the rice diet, rice—GNF diet, rice-GPI diet and rice-SMP diets were 4.08, 7.03, 7.20 and 7.35 g. respectively and the mean N retentions were 0.75, 1.44, 1.67 and 2.22 g. respectively. The apparent and true digestibility co-efficients of the proteins of the different diets were as follows: rice diet, 72.0 and 89.2; rice-GNF diet, 72.7 and 82.2; rice-GPI diet, 76.6 and 86.3 and rice-SMP diet, 76.0 and 85.5. The biological values of the different diets were 73.6, 56.0, 57.8 and 65.7 respectively. The NPU (Op) values for the different diets were as follows: rice diet, 65.6; rice-GNF diet, 46.1, rice-GPI diet 49.8 and rice-SMP diet, 56.4. The NDP-cal. per cent of the different diets were 4.80, 6.08, 6.46 and 7.55 respectively. The net available protein on the different diets were 16.7, 21.0, 22.4 and 25.9 g. as compared to the requirements of 19.3 g. of reference protein. The mean retentions of calcium and phosphorus on the supplemented diets were significantly higher than those observed on the rice diet. No differences, however, were observed in the Ca balances on the diets supplemented with the fortified protein foods or skim milk powder. All the subjects were in positive N, Ca and P balance on the different diets.

It may be concluded from the results that, in regions where milk and other protective foods are in short supply, protein-rich foods of vegetable origin such as groundnut flour or groundnut protein isolate fortified with essential vitamins and minerals could be used for overcoming the deficiencies of proteins and other nutrients in the diets of vulnerable sections of population.

4.9 Clinical studies

4.9.1 Effect of supplementary groundnut flour fortified with vitamins and minerals on the growth and nutritional status of school children subsisting on a rice diet: A feeding experiment, extending over a period of 6 months, was conducted on school children, aged 5-11 years, to assess the effect of a daily supplement of 50 g. of groundnut-flour fortified with calcium salts, and vitamins A, D, thiamine and riboflavin, on their growth and nutritional status. Forty six boys, selected for the experiment, were paired on the basis of initial height and weight and the members of each pair allotted at random to two groups. The two groups of children received the boarding home diet. In addition, the children in the experimental group were

given daily a supplement of 50 g. of fortified groundnut flour, while the control group received 25 g. each of wheat and tapioca flours.

The results indicated that supplementation of the diet of school children daily with 50 g. of fortified groundnut flour for a period of 6 months brought about a marked improvement in the height, weight, haemoglobin content and nutritional status of the children. Twenty children in the experimental group improved in their nutritional status, while, in the control group, only three children improved and five children showed deterioration in their nutritional status.

4.9.2 *The effect of a supplementary protein food based on a 4:1 blend of groundnut flour and skim milk powder on the growth and nutritional status of weaned children:* An experiment was carried out on weaned children to assess the effect of supplementing their diet with 40 g. daily of a protein food based on a 4:1 blend of groundnut flour and skim milk powder and fortified with calcium salts and vitamins A, D, thiamine and riboflavin, on their growth and nutritional status. The subjects were 92 weaned children between the age group 15-20 months, belonging to the low income groups of the population. On the basis of the initial height, weight, haemoglobin content of blood and nutritional status, the subjects were paired and the members of each pair were allotted at random to two groups. Each group contained 23 male and 23 female children.

Each child in the experimental group received daily a supplement of 40 g. of fortified protein food and 20 g. powdered sugar, while each child in the control group received 40 g. of rice flour and 20 g. powdered sugar. The experiment lasted for a period of 3 months, at the end of which, the height, weight, haemoglobin and nutritional status were measured. The results showed that a supplement of 40 g. of a fortified protein food based on a 4:1 blend of groundnut flour and skim milk powder, given daily to undernourished weaned children, brought about a marked improvement in the height, weight, haemoglobin content and nutritional status of the children. Thirty five children in the experimental group improved in their nutritional status, while in the control group only 8 children improved and ten children showed deterioration in their nutritional status.

4.9.3 *Treatment of protein malnutrition in children using a spray-dried protein food based on a blend of groundnut protein isolate, dextri-maltose and skim milk powder:* In the last annual report, the results of studies on the treatment of *Kwashiorkor* in children using blends of groundnut protein isolate, skim milk powder and casein with and without fortification with l-lysine and dl-methionine were reported. Further investigations were continued with a spray-dried protein food based on a blend of groundnut protein isolate, dextri-maltose and skim milk powder. The amount of protein contributed by groundnut protein and skim milk powder in the food was as 2:1.

Nine cases of *Kwashiorkor* in children (aged 2-4 years) were treated with the protein food. The children were given daily 85 g. of the protein food providing about 30 g. of protein. The intake of protein was about 4-5 g/kg. body weight and of calories 110 g/kg. body weight.

The results showed that diarrhoea stopped in a shorter time in children receiving the protein food as compared with those receiving skim milk powder. The spray-dried protein food compared favourably with skim milk powder in its efficacy in initiating cure of *Kwashiorkor* in children. The rate of regeneration of serum albumin in children treated with the spray-dried protein food was nearly of the same order as that observed in children treated with skim milk powder.

4.10 Design and demonstration of improved food composition and recipes for different economic levels

4.10.1 *Recipes of food preparations based on groundnut milk and groundnut curds:* A number of recipes of food preparations containing groundnut milk and groundnut curds have been standardised and the different dishes have been found acceptable. The nutritive value of these preparations has been worked out. This is being published in the form of a booklet.

4.10.2 *Recipes based on egg powder:* Work is in progress on the development of a number of recipes incorporating egg powder which can be used as supplements to children. This work has been undertaken at the instance of UNICEF.

5. Food Processing

5.1 Chemistry and technology of coffee

5.1.1 *Monsooning of Cherry coffee:*

(In collaboration with Infestation Control and Pesticides Division)

Samples of Arabica and Robusta cherry undergoing the process of monsooning at Tellicherry on west coast, were examined at fortnightly intervals.

The moisture increased from 12 per cent in June to about 16 per cent in September. The microbial load increased from about 1,000 to 8,000/g. The colour was progressively bleached and the density decreased from 1.01 to 0.94 in Arabica cherry and from 1.15 to 0.95 in Robusta cherry. There was a slight increase in the soluble solids and chlorogenic acid; decrease in sugars and trigonelline was also observed. The cup test on roasted seeds indicated that the fruitiness present in the initial sample decreased progressively on monsooning and the taste became less harsh. Also see under 2.6.1.

5.1.2 *Balloon storage:* A lot of 350 bags of Plantation A coffee was stored under polyethylene cover at Tellicherry from May 1961 to January 1962. A control lot of the same bulk was also stored at Coimbatore. In spite of the very heavy rain during the last monsoon at Tellicherry, the Plantation coffee kept well in appearance and quality. In contrast, the control lot stored at Coimbatore was considerably bleached in colour. Also see under 2.6.2.

5.1.3 *Polyethylene laminated gunny bags:* The coffee kept well during the storage period of eight months. It was, however, noted that the coffee near the seams of the bag had bleached in colour as compared to that at the centre of the bag. In cases where the coffee bags were in contact with the damp floor, the jute lining was completely damaged and the seams had given way. It may be possible to use laminated bags of improved design and strength of jute fabric for limited storage.

5.1.4 *Aluminium bin:* One aluminium bin of 400 maunds capacity of diameter 11' 8" and height 6' supplied by the Indian Aluminium Company for our trials was erected at Mangalore over a brick platform in the godown of Messrs. Aspinwal & Co. A sheet of 300 gauge polyethylene film was spread on the floor of the bin and Plantation coffee (13.8 tons) was poured from the top. The experiment lasted from May 1961 to February 1962. A control lot of the same bulk was also stored at Coimbatore. Data on moisture, colour, density, gas concentration, etc., were

collected during storage. The coffee stored well in the bin and maintained the appearance, colour, smell, moisture content and the bushel weight. No off odour or smell was noticed. The samples were found satisfactory in cup test conducted at the Institute and by two independent professional cup tasters. They reported that the coffee stored in aluminium bin was harsher in taste than that stored at Coimbatore. The ageing that had taken place during storage at Coimbatore, had probably not occurred to the same extent in the bin and the coffee, therefore, kept up its original quality and freshness.

5.1.5 Fumigation of monsooned coffee: The Coffee Board have accepted the recommendations regarding fumigation of monsooned coffee as well as the spray procedures for the control of insects in the warehouses. Quality control checks were carried out and the fumigant residues were found to be within the permissible limits.

5.1.6 Calibration of Kappa moisture meter:

(In collaboration with Coffee Research Station, Balehonnur)

Using different varieties of coffee at different moisture levels, readings were taken to construct a standard curve. Readings were also taken on various samples belonging to different grades and varieties at the various curing works at Mysore, Hunsur and Mangalore. The variations in the reading at different temperatures (75°F—100°F) were determined. After statistical analysis of the data, a suitable calibration chart giving the corrections for temperature was prepared.

5.1.7 Taint pick-up by coffee from jute bags during storage: Coffee was stored from June 1961 to January 1962 at the local curing works, using sets of 6 bags corresponding to the three different batching oil and four different percentages of batching oil. The general conclusions are as follows: (i) the taint was perceivable in samples drawn from coffee in immediate contact with bag surface containing 7.5 per cent and above of batching oil. However, the smell of coffee from the centre of the bag was normal, (ii) the smell decreased on storage, (iii) the samples stored in jute bags using conventional batching oil, had picked up more smell than the other two different lots of oil at 7.5 per cent and 10 per cent concentrations and (iv) the cup test on the bulk sample, however, did not show any off taste or odour.

5.1.8 Quality control in roasted chicory: Fourteen samples of imported chicory received from Coffee Board were analysed for moisture, solids, total ash, water-soluble ash, acid-soluble ash, alkalinity of ash and colour. They were also cup tested. The total solids ranged from 66.6 per cent to 81.9 per cent and the samples were of satisfactory quality.

5.2 Chemistry and technology of tea

5.2.1 Adulteration of tea—analysis of known blends: Since data on the changes in the proximate composition of black tea blended with

various adulterants (blackgram husk, saw dust and spent tea) were not available, it was considered desirable to analyse known blends. Moisture, total ash, water-soluble ash, acid-insoluble ash, total solids, total nitrogen, tannins, caffeine, crude fibre and petroleum ether extract were determined. The following observations are made: (1) depending on the tea, the reduction in total solids below the specified limit of 35 per cent was observed beyond 15 to 20 per cent of the adulterants in the blend, (2) in the case of adulteration beyond 20 per cent with blackgram husk and saw dust, the crude fibre also increased above 15 per cent, (3) beyond 30 per cent of adulterant, the values for caffeine may fall below 2.5 per cent (No limit has been prescribed at present under the P.F.A. rules, but a limit of not less than 2.5 per cent caffeine has been proposed).

5.2.2 Fractionation and chromatographic studies: In view of the limitations of using proximate composition data in determining the percentage of adulterant, it was considered useful to explore the possibilities of devising specific test for some constituents which are not present in tea, but are specific to the adulterants. The preliminary observations on sugar and amino acid-make up in blackgram husk did not show any significant differences between tea and the adulterant. Further studies on the above aspects are in progress.

5.2.3 Quality aspects of tea separation of major polyphenols on cellulose column chromatography: In continuation of the data detailed in the last report, fractionation of the tea polyphenols was carried out on cellulose column using water and acidified alcohol as solvents 5 c.c. fractions were collected and the adsorption at 275 m μ determined.

Four definite peaks were obtained with black tea brew. Differences in the peak position as well as in the height of the peaks were observed with different market samples. Further work is in progress to apply the above procedure for evaluating different polyphenols in tea; correlation of these with cup test will also be studied.

5.2.4 Minerals in water versus organoleptic quality of brewed tea: At concentrations of 10 to 25 p.p.m. of bicarbonate ions, a slight improvement in taste was observed; beyond 50 p.p.m., the colour of the brew became darker. With carbonates, the colour was affected beyond 20 p.p.m. Calcium content affected the extraction and caused turbidity. The extraction of colour was less beyond 50 p.p.m. and the taste was also affected. Magnesium ion did not seem to affect the extraction or taste in concentration upto 200 p.p.m. Sulphate and chloride ions in concentrations upto 300 p.p.m. did not affect the taste. Saltiness and bitterness were noticed in concentrations above 300 p.p.m. Chloride ion at 100 p.p.m. (as sodium chloride) slightly improved the taste of the brew.

The brew with distilled water was bland and was not considered satisfactory as compared to that made with water containing salts as

present in drinking water. It may, therefore, be worthwhile to use synthetic water containing different salts in optimum concentrations for brewing tea for quality evaluation.

5.3 Studies on vegetable proteins

5.3.1 *Production and utilization of groundnut protein isolate:*

(In collaboration with Dietetics Division)

1,500 kg. of groundnut cake and 220 kg. of groundnut kernel were processed in 90 different batches for protein isolation. The bulk of the air-dried protein isolate from cake was used along with milk powder for the preparation of spray-dried infant food and protein food compositions containing 18 per cent and 35 per cent proteins respectively.

5.3.2 *Studies on cottonseed:* 200 kg. lots of flaked cottonseed kernels were treated twice with 5 volumes of 0.1, 0.2 and 1.0 per cent solution of borax in a Waring blender. It was observed that this treatment did not reduce the free gossypol content to the permissible limit (0.04 per cent). Besides, there was a considerable loss of protein in the washings.

Flaked cottonseed meats were extracted with different solvents and the extracted meals were analysed for free and total gossypol content. Absolute alcohol, at the boiling point, reduced the free gossypol content of the meals to within permissible limits. Solvent mixtures containing hexane, acetone and water or hexane, alcohol and water were also efficient in the extraction of fat as well as in the removal of free gossypol. The total gossypol contents were also within limits.

5.3.3 *Effect of different conditions of drying of wet isoelectric groundnut protein on its growth promoting value:* Data on the fat and total nitrogen content of the liver and carcass of rats at the end of eight weeks on casein and the differently dried protein isolates were obtained. The results are in agreement with the earlier PER data in that there was not any significant difference in nutritive value among the protein samples dried by different methods (air-drying, drum-drying, air-cum-drum-drying).

5.3.4 *Evaluation of fractions from edible groundnut cake and protein isolates from groundnut kernel for PER:* A comparative study was made on groundnut meal and some processed fractions obtained from it.

The protein isolate was as good as the meal as regards protein quality and the removal of non-protein nitrogenous constituents as in the case of acid-washed flour or protein isolate did not result in any lowering in the nutritive value. Actually, the elimination of acid-soluble constituents from the meal by washing at the isoelectric pH resulted in slight improvement in the PER, though this was not significant statistically.

5.3.5 *Processing of soyabean pulse for protein isolate etc., and evaluation of the processed fractions for PER:* The different soya preparations

included in this study were autoclaved soya flour, acid-washed flour, heat processed emulsion from soyabean, protein isolates from this emulsion as well as from unheated emulsion and soya milk solids.

On the basis of data obtained over a period of 8 weeks the protein isolate from unheated soya emulsion had a PER significantly lower than that of other soya preparations, showing that some of the growth inhibiting factors, might still be present in the isolate prepared without any heat treatment. The proteins present in the steamed emulsion gave a PER of 1.79 and the isolate from this emulsion gave a value of 1.76, showing thereby that the isolation of protein by the elimination of non-protein nitrogenous constituents did not result in any significant decrease in the growth promoting value. The PER of the autoclaved soya flour was 1.72 and was comparable to the values obtained for the heat processed emulsion and protein isolate. Autoclaved soya flour, when washed at the isoelectric pH of 4.5, gave a product possessing a higher PER of 1.90. This could be attributed to the presence of some trypsin inhibiting activity in the autoclaved flour, indicating that the conditions of autoclaving were not quite adequate for complete destruction of the heat labile factors. Soya milk solids gave a value of 2.24 for the PER and this preparation was superior to all the other soya fractions used in the study. Whether this was due to the different processing steps, such as preliminary soaking, washing and debittering of the pulse followed by a lower pH of peptization as compared to the other cases, is being investigated.

5.3.6 Trypsin inhibitor activity in processed soya fractions: The different fractions mentioned above were found to have residual inhibitor activity of varying intensity.

Attempts were made to prepare a protein isolate free from the inhibitor by subjecting the raw material and the isolate to different conditions of heat processing.

The protein isolates from both defatted and undefatted flakes showed nearly 90 per cent trypsin inhibitor activity as compared with raw soya flour. Commercial samples of soya preparations from U.S.A. were also found to possess 50-80 per cent inhibitor activity. Autoclaving the isoelectric and neutralized protein isolates for $\frac{1}{2}$ hour at 15 lb. pressure, reduced the trypsin inhibitor activity to 40 per cent and 25 per cent respectively.

Repeated washing of the soya flakes at pH 4.2 followed by isolation of the protein did not result in a material free from the inhibitor. Protein isolate from the optimally autoclaved soya flakes had a low trypsin inhibitor activity (5.3 per cent), but the peptization and precipitation characteristics of the protein in the flakes were adversely affected resulting in lower yields of the isolate.

5.4 Studies on the processing of tur dhal (red gram dhal) and soya bean dhal and the supplementary effect of these to calcium supplemented rice diets

(In collaboration with Dietetics Division)

Red gram (*Tur*) *dhal* and soya bean *dhal* were processed under different conditions, *viz.*, traditional methods of cooking in the case of *Tur dhal* and autoclaving at 15 lb. pressure for 30 minutes at optimum moisture level to destroy the inhibitors in the case of soya bean *dhal*. The samples were evaluated as supplements to rice diet with and without added calcium.

5.5 Long term studies on choline deficiency in rats fed on groundnut protein isolate

Estimation of nitrogen in liver tissues showed that changes in the apparent concentration of nitrogen in the dry liver were, for the most part, caused by changes in the fat content. Non-protein nitrogen increased from 0.84 per cent in the 5th week to 1.16 per cent (on dry wt. basis) in the 9th week in the choline-deficient group whilst, in the other three groups, the values were not significantly different during those periods.

The fatty infiltration in the livers at 5 weeks was 26-30 per cent on fresh weight in the high protein-hypolipotropic diet as compared to 11 per cent in the livers of rats on a low protein-hypolipotropic diet. The liver fat was only 4.8 per cent on the high protein-lipotropic diet.

The major increase in liver lipids (stainable fat) was concurrent with a significant decrease of liver phospholipids in the choline deficient group.

The livers of rats on the low protein-lipotropic diet exhibited zero xanthine oxidase activity, probably due to the low biological value of groundnut protein and the low level of protein in the diet.

The histological studies provided evidence that fatty metamorphosis of the liver by itself did not lead to hepatic necrosis or cirrhosis and that, even at the stage of abnormal fatty infiltration, parenchymal damage had not taken place.

5.6 Vegetable milk project

5.6.1 Production: Production and sales of vegetable curd to interested parties in Mysore City was continued.

5.6.2 Flavour and setting quality of vegetable curds:

(In collaboration with Regional Research Stations Division)

Addition of small amounts of common salt (0.05-0.10 per cent) to groundnut milk, prior to lactic fermentation, was found to improve the flavour and palatability of the curd. The curd, had, however, a loose set with slight exudation of whey. Among the essential oils, clove and cinnamon oils imparted a pronounced flavour to the product and were found to be unsatisfactory. Lime oil at optimal concentrations gave an agreeable flavour to the curd.

5.7 Dehydration technology

5.7.1 Dehydration of green peas: Thirty three varieties of peas obtained from Uttar Pradesh were sown at the Institute farm and green peas of two stages of maturity were dehydrated. Cooking tests indicated that, in peas harvested 60-70 days after sowing, cooking times were longer than those corresponding to peas of advanced maturity (harvested 80-90 days after sowing).

An acceptable product can be prepared by grading the peas with reference to maturity by brine floatation method, slitting the seeds, steeping them in 2 per cent sodium carbonate solution for 30 minutes, washing in water, blanching for 3-4 minutes in boiling solution containing 0.1 per cent sodium bicarbonate, 0.1 per cent magnesium oxide and 0.4 per cent potassium metabisulphite and drying in a cross flow-drier having an air velocity of 3-4 meters per second and using a tray load of 5-6 kg/sq.m. at 85°C for $\frac{1}{2}$ hour, 80°C for $\frac{1}{2}$ hour and 70°C for 2 hours. Final drying to about 5 per cent moisture is done at 60°C for 4 hours in a through-flow drier with an air velocity of 1 m./sec. using a tray load of 25-30 kg/sq.m.

The storage tests showed that the dehydrated product with about 5 per cent moisture packed in aluminium foil laminated bags or sanitary cans will have a shelf-life of about 6 months at 37°C or one year at room temperature (24-30°C).

Preliminary experiments to colour the pod-dried peas with a view to preparing a cheap dehydrated product comparable to canned processed peas, showed that the best method of imparting colour was to add it later at the soaking stage which was of 8 hours duration. During pressure cooking, uptake of colour was not satisfactory. Optimum concentration of colour was 0.002 per cent blue VRS+0.02 per cent tartrazine yellow added in the ratio of 1:4. Addition of sodium hexametaphosphate (SHMP) and sodium bicarbonate (17.9 g. SHMP+2.1 g. NaHCO_3 per kg. of peas) during cooking, did not help in softening the product. The dried product should be reconstituted in five times its weight of water to obtain green coloured product.

5.7.2 Cauliflower: Among the three commercial varieties of cauliflower, *viz.*, *Holland*, *Sutton* and *Pusa-16 snow-white* grown in Uttar Pradesh, the last has been found to be the best for dehydration. The dehydrated product cooks in 10 min. in boiling water after soaking in water for 2 hours. Of the three varieties, it contains the maximum amount of ascorbic acid *i.e.*, 164.4 mg. per cent.

5.7.3 Carrots and potatoes: At the request of the Defence Food Research Laboratory, Mysore, about half tonne each of carrots and potatoes was dehydrated and packed under nitrogen in A2 $\frac{1}{2}$ cans.

5.7.4 Dehydration of grapes: Several varieties of grapes [*Bangalore Blue*, *Bhokri*, *Selection 7*, *Selection 94*, *Kandhari*, *Gulabi*, *Pachhai Prakshai*, *Kishmish* (seedless), *Anab-e-Shahi* and *Black Prince*] were obtained from

important growing regions with a view to studying their suitability for dehydration. The results show that, while it is possible to prepare good quality raisins from *Kishmish* (seedless), *Pacchai Drakshai* and *Gulabi* by drying them as such, incorporation of sugar by syruling is necessary in other varieties as their brix is below 18° and acidity, in most cases, is rather high.

5.7.5 Dehydration of green mangoes for use in pickles and chutneys: *Safeda* and *Badami* varieties gave the maximum drying yield while the local variety give the minimum because of the latter's fibrous pulp and higher proportion of stones. Ascorbic acid content was also more in *Safeda* (230 mg per cent) and *Badami* (63.8 mg per cent) as compared to 41.3 mg per cent in *Raspuri*, 39.5 mg per cent in *Totapuri* and 2.3 mg per cent in *Mulgoa*. Storage studies on products prepared from different varieties are in progress.

5.7.6 Soup powders:

(In collaboration with Packaging and Containers Division)

Packaging and storage studies on five recipes of soup powders standardised last year are in progress. The results obtained so far, indicate that: (i) aluminium foil laminated bag is a suitable packaging material and (ii) it is necessary to pack the products at a moisture level of 3-4 per cent for ensuring reasonable shelf-life at 37°C.

5.7.7 Dehydrated rice and tur dhal: At the request of the Defence Food Research Laboratory, Mysore, experiments on the preparation of quick cooking dehydrated rice and *tur dhal* were conducted. The results showed that: (i) steam cooking of rice for 10 minutes with $1\frac{1}{2}$ to $1\frac{1}{2}$ times water and 3 per cent fat and dehydrating at 70°C in a cross-flow drier for $2\frac{1}{2}$ —3 hours gave the best product which reconstituted in 3 times the boiling water in 4-5 minutes, (ii) addition of fat helps in keeping the cooked rice grains separate and avoids lumping, (iii) for large scale production, steam cooking should be done in a steam cabinet using aluminium trays to which required amount of water is added along with washed and thinly spread rice. Use of large sized vessels or steam jacketted kettle for cooking may not be practicable and (iv) precooked *tur dhal* of good quality can be prepared after cooking in a pressure cooker at 10 p.s.i. for 5 min. and dehydrating at 70°C for $2\frac{1}{2}$ to 3 hours in a cross-flow drier. The product reconstitutes well in $1\frac{1}{2}$ time the boiling water in 7-8 minutes.

5.7.8 Tapioca flour: A pilot plant trial on the dehydration of 5 tonnes of tapioca was carried out using a commercial tunnel drier. In the absence of satisfactory peeling device, the dehydration had to be spread over 4 days. The spoilage progressively increased with time with the result that the yield of the dehydrated material was 25 per cent instead of the expected 32 per cent. Steeping in 0.2 per cent bleaching powder or 0.1 per cent NaOCl solution was found to protect the tubers from spoilage

for about 10 days. The trial served to pin point the importance of processing the tubers with extreme rapidity after harvest and the necessity of fabricating a satisfactory peeling device capable of completely removing the inner rind.

5.7.9 Dehydrated mutton mince: Storage studies have shown that the dehydrated product, when nitrogen packed and with a moisture of 3-4 per cent and fat content of less than 25 per cent, is acceptable upto 6 months storage at 37°C and one year at room temperature (24-30°C).

5.8 Coconut technology*

5.8.1 Coconut proteins in processed protein foods:

(In collaboration with Dietetics Division)

When ripe coconuts are processed by the wet rendering process of Krauss-Maffei, the water phase, obtained on removal of the oil fraction by centrifugation, contains most of the protein, carbohydrates and the salts. On concentration in vacuum, this phase yields a honey-like viscous liquor, generally known as 'coconut honey'. It contains about 26 per cent protein on dry basis. If the skimmed milk, after centrifugation of the fat, is coagulated either with acid at pH 4.0 or by heating at 85°C, a coagulate separates, which could be separated from the whey and used in place of honey in the preparation of foods. The coagulate contains 83 per cent of the crude protein present in the skim milk of coconut.

Two types of products have been prepared using coconut honey. (a) Spray-dried infant food (26 per cent protein) and protein food (36 per cent protein). Of the total protein, $\frac{2}{5}$ th is derived from coconut, $\frac{2}{5}$ th from groundnut and $\frac{2}{5}$ th from skim milk powder. (b) Roller-dried flakes using a blend of coconut honey, groundnut protein isolate and a cereal—rice, wheat or *ragi*. These contain 26 per cent protein comprising 1 part from cereal, 2 parts from coconut and 3 parts from groundnut.

The NPU value of coconut honey and the protein food was found to be 35 and 63 respectively. The PER of the protein food was 2.63.

Among the roller-dried flakes, there was no significant difference in the PER values between the cereals used *i.e.*, rice, wheat or *ragi* (2.12, 1.95 and 1.90 respectively). The PER values of rice + coconut heat coagulate and wheat + coconut heat coagulate, were 2.69 and 2.19 respectively.

5.8.2 Method of isolation versus PER of coconut protein: The PER values of protein in coconut honey, acid coagulate and heat coagulate were found to be 1.91, 2.43, and 2.2 respectively.

* Dr K. J. Carpenter of The School of Agriculture, University of Cambridge, was also associated with studies on coconut proteins.

5.8.3 Effect of minerals in coconut honey on its PER: Coconut honey has a high salt content (ash, 10-12 per cent on dry basis) and $\frac{2}{3}$ of the salts are reported to be potash salts. An experiment designed to know whether the low PER of honey as compared to the coagulate was due to the high mineral content, has shown that the salts, at the levels present in honey, have neither a depressant nor a beneficial effect on the growth of rats.

5.8.4 Trials with Krauss-Maffei process: Further experiments have shown that, if once pressed residue is rewetted and passed again through the press, a better extraction of protein and oil is obtained. It was also observed that the steaming of the coconut before shelling seems to have an adverse effect on the extraction of oil and protein into the coconut milk.

A few preliminary trials with the redesigned worm (compression ratio 12:1 in contrast with 5:1 for the first worm) have indicated that it is possible to extract 95-97 per cent oil even in a single pass through the press. Trials with large batches will be undertaken to obtain the yield-data.

5.8.5 Processing of expeller cake: The expeller cake has an average protein content of 22-26 per cent, but has limited use for human food as a result of its high fibre content (14-16 per cent). The extraction of protein from the cake according to the conventional method, gives a poor recovery because the proteins are denatured during the process of heating and expelling.

Microbial digestion of the cake by *R. oryzae* and subsequent extraction with acid and alkali solutions did not give satisfactory extraction of protein.

Repeated extraction of the cake with water at 60°C for 30 minutes, gave an overall recovery of over 60 per cent nitrogen in cake. Further work is in progress.

5.9 Cereal and confectionery technology

5.9.1 Enriched wheat macaroni: The blend consists of wheat semolina—90 per cent, casein—7 per cent, skim milk solids—3 per cent, added vitamins and minerals. The extruded product was passed through the pre-drier and steamed for 1½ min., followed by drying under conditions normally used for wheat macaroni.

The cooking quality of the product is excellent. It takes about six minutes to cook in boiling water. The PER values of wheat macaroni, wheat macaroni + lysine at 2.5 per cent on protein basis, enriched wheat macaroni and enriched wheat macaroni + lysine at 2.5 per cent on protein basis, were 1.10, 2.11, 2.48 and 2.63 respectively; additional fortification of enriched macaroni with lysine slightly enhanced the PER, but the difference was statistically non-significant and, the mean values for fresh liver weights and liver nitrogen content of animals fed with fortified

macaroni, were significantly higher than the corresponding values for the livers of control group, which contained significantly more fat.

5.9.2 Use of groundnut protein isolate: Freshly prepared batch of wet protein isolate was used on the basis of 20 per cent dry solids in conjunction with 80 per cent soft wheat semolina for preparation of high protein macaroni. No extra amount of water was required to make the dough which was easy to extrude in the ATA press. The cooking quality of the product was superior to the product of semolina alone, but it had a grey colour.

5.9.3 Enriched tapioca macaroni: The samples of the formulations C (tapioca flour—35, groundnut flour—25, semolina—30 and skim milk solids—10 per cent) and D (tapioca flour—35, groundnut flour—25, semolina—25, and chickpea flour—15 per cent) were stored at room temperature and at 37°C in 1 lb. capacity sealed polyethylene bags (250 gauge) with and without an outer paper carton.

The product C stored much better than the product D which developed oxidative rancidity within a month. Vitamin A was found to be comparatively more stable in the product C; the losses in thiamine and riboflavin were negligible in both the cases.

In the preparation of product D, unprocessed chickpea flour was used which seemed to catalyse oxidative rancidity in the finished product. Use of flour prepared from pre-steamed chickpea splits considerably improved the palatability of the product. Shelf-life of this sample is being studied.

5.9.4 Nutro biscuits: The PER of commercially baked biscuits was found to be 1.35 which confirmed our earlier findings on laboratory baked samples. The amount of available lysine in biscuits (2.5 g/100 g. protein) was determined by the method of Carpenter (*Biochem. J.*, 1960, **77**, 604). There was very little loss of lysine as a consequence of baking.

5.9.5 Studies on the stabilization of groundnut flour: The processing conditions employed in a local oil mill for the preparation of edible cake were studied on two occasions. There was no consistency in the values either for moisture content or for the residual enzyme activity in the cake. On storage, the double pressed cake flour developed oxidative rancidity faster than the single pressed cake flour which, however, developed higher percentage of free fatty acids.

To determine optimum conditions of processing for the production of stabilized meals, kibbled groundnut kernels were steamed at 212°F and 240°F at the initial moisture level of 6.0 and 12.0 per cent. Excess oil from the treated and control samples was removed in the Carver press. The residual meals containing 21.7 to 26.3 per cent oil were stored in air tight tins at 37°C for over 12 weeks. The samples were examined periodically for organoleptic quality as well as for development of FFA and peroxides.

The results indicated that, though there was more inactivation of lipase in the sample steamed at higher initial moisture content, there was increased formation of peroxides suggesting thereby a greater destruction of the natural antioxidants.

In view of the alleged role of lipoxidase in the deterioration of flavour of various foods, a study of lipoxidase enzymes in groundnut was undertaken. The method of Koch *et al* (*Arch. Biochem. & Biophys.*, 1958, **78**, 165) was modified and adopted for measurement of the lipoxidase activity, which was considerably more in the germ portion than in the kernels. Optimum pH for maximum activity was around 6 for the germs and 8 for the degermed kernels. At low levels of enzyme concentration, there was low activity which after a certain enzyme concentration increased linearly.

5.9.6 Colorimetric method for the determination of FFA in groundnuts: The method is based on the reaction of fatty acids in benzene solution with cupric acetate; conditions for the linear relationship between absorbance and the concentration of fatty acids were established. The values estimated by this procedure agreed closely with the values determined by titration.

5.9.7 Active dry baker's yeast (ADY): It has been confirmed that the shelf-life of the dried product is influenced greatly by its moisture content. At higher temperatures around 40-43°C, yeast deteriorates very fast at moisture levels of 8-9 per cent; the shelf-life is appreciably extended if the moisture content is maintained at 2-3 per cent.

5.9.8 Tamarind juice concentrate: Several batches were prepared to obtain data regarding the yield and the proximate composition of the concentrate. The tartaric acid content in different batches averaged about 14 per cent. Total solids showed a range of 65-75 per cent. Conditions for maximum extraction of solubles from the pulp have been worked out.

Studies on the anthoxanthin pigments of tamarind have shown that the leaves are rich in anthoxanthins but almost the entire yellow colour of flowers is due to xanthophylls. Chromatographic separation has revealed that the pigments in the water extract of tamarind leaves bear close resemblance to apigenin and luteolin.

Chromatographic studies on *Garcinia cambogia* (Malabar tamarind) have shown that the main acid in this fruit is neither tartaric nor citric. The acid has not yet been characterised.

5.10 Technical aid to the industry

5.10.1 Tamarind juice concentrate: Messrs F. K. Research Products, Mysore, have been making 'tamarind juice concentrate'. The pilot plant facilities at the Institute are being used by the firm. The product is to be exported to U.S.A. and Australia.

5.10.2 *Dehydration of foods:* Twenty parties including some State and Central Government Departments were furnished with technical information on the dehydration of foods such as peas, bananas, soup powders, onions, potatoes, in addition to the technical *know-how* in respect of accelerated freeze-drying, types of dehydrators, model schemes, etc.

5.10.3 *Coffee:* Advice regarding conforming to the specification of coffee powder rendered to the army; formulation of specification for chicory on behalf of I.S.I.; advice regarding roasting of chicory; supply of project reports on the manufacture of soluble coffee; and technical advice to Coffee Board on various technological problems, have been attended to.

5.10.4 *Cereal technology and confectionery:* Two samples of biscuits and four samples of starch received from the industry were analysed for various constituents. A representative of a flour mill was trained in the analysis of flour and wheat products. Technical aid was rendered to the cereal processing and confectionery industry by answering a number of enquiries.

5.10.5 *Desiccated coconut:* Advice was given to several industrialists who wanted to establish factories for the manufacture of desiccated coconut and copies of project report were made available.

6. Fruit Technology

6.1 Spin-pasteurization of canned fruit products

Comparative sets of spin- and still-heat processed canned guava slices in syrup and guava pulp were prepared and analysed immediately after processing and after 6 months' storage at room temperature. Losses in ascorbic acid in the two products were 16-19 per cent during spin-processing and about 15 per cent during 6 months' storage at room temperature. The corresponding losses in the still-processed products were somewhat more. In canned pineapple juice, the entire vitamin C was lost during 21 months' storage, while in pineapple concentrate, the loss was of the order of 54 per cent, the difference between spin- and still-processed concentrate being negligible. After 15 months' storage, spin-processed mango pulp retained 40-45 per cent vitamin C and 80-86 per cent carotene, the retention of the two constituents in the still-processed mango pulp being 3.5 per cent less.

Several sets of cashew apple products like juice, ready-to-serve beverage, cordial, squash and blends with mango and papaya pulps were spin-processed in 202×212 can, for one minute in steam, followed by spin-cooling for $1\frac{1}{2}$ min. The loss in ascorbic acid, carotene and flavour of the products during processing was negligible. During storage for about 5 months at room temperature, the spin-processed products remained in good condition and scored higher than other comparative sets preserved by ordinary pasteurization, benzoation and sulphitation.

6.2 Fabrication of equipment

The fabrication of a motorized Pipkin roller press was completed, while that of a motorized rumbler is nearing completion. The fabrication of a continuous spin-pasteurizer was taken up. Performance tests were conducted with the hot preserve unit.

6.3 Pectin and papain from raw papaya

(In collaboration with Engineering Division)

Papain was extracted from 133 papaya plants at the sewage farm, Mysore. The total yield of papain in 4 tappings was about 450 g. for 10 plants. The tapped fruits were utilised for the preparation of pectin. Data were collected on the preparation of pectin in larger batches. Pectin prepared from the fresh unpeeled papaya was white in colour, while that prepared from the dried unpeeled fruit was slightly brown. It is, therefore, necessary to peel the fruits, if they are to be dried for subsequent extraction of pectin. Rasping of the pulp to about 30 mesh size

facilitated the removal of non-pectic water-soluble matter and also helped in the better extraction of pectin than mincing to 16-18 mesh or slicing to $\frac{1}{20}$ " thick pieces. Experiments were conducted to reduce the number of extractions, avoiding the pressing of the pulp after each extraction. The optimum ratio of pulp to extracting acid (0.2 per cent HCl) was 1:7 in the case of fresh, rasped and pressed pulp and 1:40 in the case of dried pulp. In either case, the recovery of pectin was 93-98 per cent in 2 extractions of 45 minutes each. The spent pulp contains nearly 6 per cent protein and 88 per cent crude fibre and is not, therefore, quite useful as a cattle feed.

The production of papain and pectin from the 5 acre papaya plantation was started in November, 1962. In the first crop (ending on 1-2-1962), only 477 plants were bearing fruits and these yielded 8.7 tons of papayas and 27 kg. of papain. All the lanced raw papayas were processed and dehydrated in a tunnel drier for the subsequent preparation of pectin. The rasped material dried in $4\frac{1}{2}$ —5 hours in the tunnel drier by maintaining the temperature at 70°C for 2 hours, then at 60°C for 2 hours and finally at 50°C. In the 2nd crop (ending on 31-3-1962), 1,120 plants were bearing fruits and these yielded 12.7 tons of papayas and 62 kg. of papain. The lanced fruits were partly dehydrated in the tunnel drier and partly utilized in the fresh condition for the extraction of pectin. In the third crop (ending 30-6-1962), about 1,500 plants were bearing fruits and these yielded 84.5 kg. of papain.

So far, 163 kg. of papain, 55 kg. of pectin and about 600 kg. of dry pulp containing 18-25 per cent pectin, have been collected from the above plantation from November, 1961 to June, 1962. 75 kg. of papain have been sold to a firm.

Storage studies on the dried papaya pulp were undertaken. There was no deterioration either in the yield or quality of pectin from the dried pulp after six months' storage in open gunny bags at 25-30°C (R.T.). The critical relative humidity for this product was found to be 60 per cent.

Effect of extraction of papain on the physical and chemical composition of papaya at various stages of maturity has been studied. The ripening characteristics of the fruit, when allowed to ripen on the tree itself and also when allowed to ripen at room temperature, after picking, were also studied. Three products, *viz.*, canned papaya pulp, papaya powder and papaya leather, were prepared from the tapped and untapped fruits to compare their organoleptic quality as well as stability during storage at different temperatures. In general, lancing had no effect on the growth and the quality of the fruit. In lanced fruits, however, the protein content was slightly less and the ascorbic acid content considerably more than those in the control samples. After picking, lanced fruit ripened 3-4 days earlier than unlanced fruit. Colour, taste and flavour were not affected to any extent by lancing. The products prepared from lanced as well as unlanced fruits had practically the same colour, taste, flavour and storage stability.

6.4 Utilization of mandarin waste to obtain pectin

Upto 9 months' storage of the mandarin waste at room temperature (24-30°C), there was very little deterioration in the quality or recovery of pectin. At 37°C storage, however, there was some deterioration in colour and yield of pectin. Besides, the pectin recovered from it was also of inferior colour as well as quality. After 12 months' storage, there was a decrease in the jelly grade (180-185) of the pectin recovered. Similarly, the jelly grade of powder pectin also, stored at room temperature and at 37°C, came down to 150. The yield of pectin in the case of greenish yellow fruits having a °Brix/acid ratio of 13.6:18.6 was slightly higher than in the case of green or yellow fruits. Samples of dried pomace got from Messrs NOGA, Nagpur contained about 19.7 per cent of pectin of 160-170 jelly grade. It is noticed that the method of drying has to be improved to get pectin of a higher jelly grade.

6.5 Utilization of lime waste

Lime marc packed in ordinary gunny bags got infested, while that packed in laminated bags or in cans, remained in sound condition upto 6 months' storage. The insect is being identified. It is proposed to store the dried material in bins.

The optimum time of rumbling for green, greenish yellow and yellow limes for the extraction of lime oil was 3, 2.5 and 2.0 minutes respectively. Beyond this limit, there was a loss of 6-10 per cent in the total yield of pectin. Recovery of pectin was the highest in the case of green fruits and it decreased with advancing maturity. The equilibrium relative humidity (ERH) for lime marc having 7-9 per cent moisture, was 38 per cent at R.T. Extraction of lime juice using less pressure helped in the better retention of colour in the juice concentrate.

6.6 Utilization of cashew apples

In the case of the juice and the blends packed in glass bottles, the losses in ascorbic acid at R.T. and at 37°C were 20 per cent and 25 per cent at the end of 16 weeks and 40-50 per cent and 53-66 per cent at the end of 36 weeks, respectively. Packing in plain or lacquered cans reduced the loss of ascorbic acid, the loss at the end of 36 weeks' storage being 30 per cent at R.T. and 50 per cent at 37°C.

In sulphited juice concentrate containing 600 p.p.m. SO₂, the retention of ascorbic acid was 70 per cent at R.T. and only 15 per cent at 37°C. In pasteurized concentrates, stored in glass bottles for 36 weeks, the retention of ascorbic acid was about 60 per cent at R.T., but only 18 per cent at 37°C. When cans were used as containers, bulging was noted even at R.T. within a very short time. This might be due to either production of carbon dioxide as a result of non-enzymatic browning, or hydrogen swell.

It was noticed that both red and yellow varieties of cashew apple had practically the same amino acid make-up. Out of the 9 bands found on the chromatograms, 7 were tentatively identified as threonine, leucine, valine, alanine, proline, serine and aspartic acid. Proline and serine were in traces only, while valine and aspartic acid were found in higher concentrations.

In small unripe fruits weighing 1-4 g. there was very little of true ascorbic acid, most of it being apparent. Polyphenols were quite high in the initial stages, but got gradually oxidized during ripening. This interfered considerably in the estimation of sugars; clarification of the juice with lead acetate was quite essential.

Among the various treatments tried, such as sun drying, sulphuring and sulphiting, sulphited samples of cashew apple residue were found to have the best appearance as judged by tintometer and colorimeter readings.

Cashew wines with high initial vitamin C content retained more than 55 per cent of the vitamin, even after 6 months' storage at room temperature.

The strain of yeast (*C. krusei*) isolated from fermented cashew apple juice, using 200 to 800 p.p.m. benzoic acid and sulphur dioxide separately, failed to grow at 400 p.p.m. of sulphur dioxide and 800 p.p.m. of benzoic acid, when cashew apple juice (pH 4.1) was used as a substrate.

6.7 Fruited cereals

Mango cereal flakes of low sugar content were prepared to assess consumer acceptability of the product, especially abroad. Cereal flakes prepared by blending papaya pulp with mango pulp in different proportions, were found quite acceptable. Studies on the preparation of flakes from other fruit pulps was continued.

6.8 Strained baby foods

Conditions were standardised for canning acidified banana puree. Among the five varieties screened for the purpose, *pachabale* was outstanding as regards colour, flavour, consistency and smoothness. Addition of ascorbic acid caused browning of the product during storage, especially at elevated temperature (37°C).

Among the several blends of strained mango and papaya pulps tried, a 65:35 blend was found suitable. The blend was mixed with citric acid and sugar with a view to improving the palatability and also minimising the processing time.

Preliminary experiments indicated that a blend of strained peas and carrots was of promise as a strained vegetable.

6.9 Fruit juice powders

Conditions were standardised for preparing guava juice powder by puff-drying technique, using guava concentrate prepared from enzyme-clarified guava juice. Addition of cane sugar at the rate of 1:1:5 was found satisfactory. The dried product was light, fluffy and porous in texture, but was highly hygroscopic. It was white in colour, with characteristic guava flavour, and the coarse powder had a bright crystalline appearance. There was practically no loss of ascorbic acid during the drying process, and the final product contained nearly 277 mg. per 100 g. of ascorbic acid and 40 per cent of juice solids.

6.10 Dehydration of mixed fruit pulps

Mango and banana pulps, mixed in the ratio 2:1, were dried in an atmospheric double drum drier. The dried product was yellow in colour with a predominant banana flavour.

6.11 Bulk storage of mango pulp

Storage studies on mango pulp packed in bulk quantities in wooden barrels, in the presence of added SO_2 and also packed in different sizes of tin containers, with and without heat processing, gave promising results.

6.12 Indian preserves

The pilot-plant equipment of about 300 lb. capacity, fabricated at the Institute workshop, was found satisfactory for the preparation of carrot preserve by the hot continuous process at a constant temperature of $60^\circ \pm 2^\circ \text{C}$.

Systematic animal feeding trials have been started recently using myrobalan preserve to verify some of the medicinal values traditionally attributed to such preserves.

6.13 Preservation of sugarcane juice

Among the various blends studied, those with lime juice, orange juice and pineapple juice gave good results. These blends kept well after heat pasteurization. Blends with lime juice and oleoresins of black pepper and ginger also were not only good but also had good keeping quality. Further work is in progress.

6.14 Canning of drinking water

In connection with the supply of canned drinking water for emergency use by the Defence Forces, about 2000 cans were packed and supplied to some of the Air Force Stations and also Naval Stations in the country.

6.15 Experiments on molasses

Some samples of molasses were analysed and the results were as follows: pH—4.6; refractometer solids—84.0 per cent; total ash—

6.7 per cent; acidity (as anhydrous citric acid) 1.17 per cent; reducing sugars (as invert sugar)—23.1 per cent; total sugars (as invert sugar)—54.2 per cent and non-reducing sugar (as sucrose)—29.55 per cent.

Molasses could be converted into powder by the addition of calcium oxide. This powder did not contain any extractable reducing sugars, but it contained about 17 per cent of non-reducing sugars, expressed as sucrose, as against calculated value of 22.7 per cent. Further work is necessary to confirm these findings.

6.16 Ginger and mango ginger

Pre-treatment of the peeled ginger by dipping in CaO solution before drying was found to improve the quality of the product. Direct drying resulted in the development of a red colour in the ginger. The CaO content of the covering liquid was 0.12 per cent, while those of fresh ginger and of ginger that was soaked for 3 and 24 hours and dried ginger was 0.03 per cent, 0.11 per cent, 0.25 per cent and 0.54 per cent respectively.

Some work was carried out on the chemical composition, including volatile oil, oleoresin, crude fibre, water and alcoholic extracts, of local as well as *Kalimpong* variety of ginger. The flesh and the peel of ginger had a volatile oil content of 0.5—0.7 per cent v/w. Crude fibre and ash content of *Kalimpong* ginger were rather high (7.9 per cent and 8.1 per cent respectively). The corresponding figures for the local ginger were 4.6 per cent and 7.3 per cent respectively. Time taken for sun drying was about 35 hours for the local variety and 45 hours for the *Kalimpong* variety. The lead content in local ginger was less than even 1 p.p.m.

Peeled ginger was found to develop a pinkish red colour during drying. The ginger gave a positive test for leucoanthocyanins. The pigment was extractable with dilute HCl and it was anthocyanin. Absorption spectra of the crude pigment gave a peak at $535\text{ m}\mu$ which indicated that it might be cyanin. The sugar residue gave only one spot, corresponding to glucose.

Work on essential oil, oleoresin, preserve and candy from mango ginger was completed and the results communicated for publication.

6.17 Enzymatic clarification of fruit juices

Experiments on the clarification of fruit juices from guava, banana, sapota, apple, lime, etc., by using a commercial enzyme preparation, were completed.

Conditions were standardised for the production of juice from Allahabad variety of guavas obtained from the Institute orchard using 'pectinol'. The yield of juice on the basis of the whole fruit varied from 70 per cent to 75 per cent. Both cloudy and clear juices were prepared, canned and

bottled. There was sedimentation during storage in the cloudy juice, but there was no such sediment in the case of bottled clear juice. A brix/acid ratio of 38:44 was satisfactory. Guava juice, thus prepared, had strong guava flavour. Retention of flavour was better in the sweetened product during storage. There was no significant loss of ascorbic acid in the juice during 6 months' storage at room temperature.

The local red variety of pink fleshed guava was not found suitable for the preparation of juice. It contained very little of β -carotene. However, a nectar having delicious flavour and an attractive light red colour, could be prepared from the inner flesh.

Guava juice was concentrated using forced circulation as well as thin layer evaporators. There was practically no loss of ascorbic acid during different stages of concentration in a thin layer evaporator. The viscosity of the concentrate was not appreciable upto 50°brix, but it became high when the brix reached 67°. The concentrate was cut-back with the fresh juice to restore the lost flavour, filled into cans and stored at 0°F until further use. It had good flavour and colour. Heating the concentrate to 80°C for the purpose of canning was not practicable, as it imparted a dark brown colour to the product.

Banana juice of good quality was prepared from *pachabale* variety by treating the pulp with 'pectinol'. The juice had good body and flavour and was brilliantly clear. Pasteurization of the product, however, caused sedimentation, resulting in a concomitant reduction in the body of the juice.

Preliminary experiments on the preparation of a juice powder from banana juice concentrate were not encouraging, as the resultant product was highly sticky and did not dry properly.

6.18 Analysis of mango varieties

Thirteen varieties of mangoes (including four hybrid varieties) received from the Horticultural Station, Kodur, were analysed for important constituents with a view to assessing the quality of the hybrids developed in that Station. The hybrid, *K.O. 16*, is unique in that it is far richer in ascorbic acid and β -carotene than the other varieties. The flavour and taste also are pleasant. The fruit is, however, rather small in size.

6.19 Experiments on banana stem

(In collaboration with Arecanut Technology Unit and Packaging and Containers Division)

Banana pseudostem consists of two component parts *viz.*, the fibrous portion and the central core. These and the centrifuged juice were analysed for their proximate composition. Data were collected on the preparation of fibre and extraction of starch from banana stem by the following two methods: (i) by crushing the stems in a power driven cane

crusher; and (ii) by beating the cut pieces in a pulp beater. More of the starch present in the stem could be extracted by beating than by crushing alone. The yield of fibre, however, decreased by about 1.0 per cent. Increasing the number of crushings from 2 to 5 did not improve the yield of starch much. The yield of fibre was not much affected by repeated crushing. Although crushing of stems soon after removal from the field is more advantageous, the effect of soaking overnight and then crushing on the yield of starch and fibre was not significant. Repeated beating for a longer time slightly improved the yield of starch. It had, however, an adverse effect on the yield of fibre. The fibre obtained from longer beating and repeated beating was much whiter. On storage of stems at R.T. in the shade, the yield was not affected.

Conditions were standardised for digesting banana fibre by the caustic soda process. Trial batches of paper sheets were prepared, tested and data collected on their quality and strength. Since this process involves costly equipment for the digestion of fibre into pulp, other methods were tried. They were: (i) nitric acid digestion and (ii) *Vasconocellos* or *Batex* process (soda ash process).

The method involving nitric acid digestion is economical and does not need costly equipment, but it seems to affect adversely the yield of pulp and the strength of the final paper.

The soda ash process gives an yield of 43 per cent of pulp which bleaches well. Paper sheets prepared out of this pulp were found to be quite strong and white in colour. Time required for draining also was low. This process does not involve costly equipment and appears to be economical. Further work is in progress to standardise the conditions to convert banana fibre into pulp by this process.

Further details regarding the consumption of chemicals, yield of pulp, strength characteristics of the paper prepared from it, etc., are given under 7.5 and 11.12.1.

6.20 Pink discolouration in canned cabbage

Among the three varieties examined, the *Ooty* variety developed more pink discolouration as compared to the *Bangalore* or the local variety. The pink discolouration appeared to increase with increasing maturity. Variation in blanching time or processing time and temperature did not inhibit development of pink discolouration. Leucoanthocyanins, which are found to be responsible for similar discolouration in banana, etc., could not, however, be detected in raw cabbage. Although cabbage is rich in sulphur compounds (124 mg. per cent in the stem portion and 55 mg. per cent in the leafy portion on fresh weight basis), experiments hitherto carried out did not reveal the pink discolouration as being due to the sulphur compounds present therein. The pink discolouration is progressively reduced with increase in pH of the covering brine.

6.21 Bitterness in custard apple pulp

The insoluble fraction of the pulp was found to be responsible for the bitterness that develops in the pulp on heat treatment. The serum fraction did not turn bitter. Addition of 'pectinol' did not aid much in the separation of the clear serum from the pulp. Adequate quantities of the pulp were preserved for carrying out consumer acceptance trials.

6.22 Firming of mango slices

Experiments were conducted on firming of mango slices by dipping them in 0.5 per cent and 1.0 per cent CaCl_2 solutions for 15 minutes. A dip method of this type was not found to be advantageous. The mango slices in the untreated control pack were firmer than those in the treated lot. This may be due to excessive handling of the slices during the treatment. Experiments are in progress to study the effect of addition of calcium succrate and calcium chloride, along with the syrup.

6.23 Avocado pulp

Avocado is a highly perishable fruit. The skin retains the green colour even when the fruit is fully ripe. Fruits which were just soft, indicating full maturity, were taken, the pulp and stones separated and the pulp taken for analysis. From an examination of 140 fruits, the following data were obtained: average weight of fruit, 273 g.; yield of pulp, 45 per cent; peel, 29.0 per cent; and stones, 25 per cent.

Proximate composition of Avocado pulp from fruits with pink and green skins was determined separately. There was not much difference between the two varieties and the average values were: moisture, 78 per cent; total ash, 0.9 per cent; acid soluble ash, 0.8 per cent; ether extractives, 13 per cent; protein, 2.1 per cent; total reducing sugars, 2.6 per cent; free reducing sugars, 2.25 per cent; calcium, 8.6 mg. per cent; phosphorus, 43.0 mg. per cent, ascorbic acid, negligible, β -carotene, 1050 μg per cent and acidity (as anhydrous citric acid) 0.2 per cent, on fresh weight basis.

The pulp contained a strong peroxidase which could be inactivated by heat treatment. Studies on the storage behaviour of the pulp, as also of the freeze-dried pulp, are still in progress. In addition, the possibility of utilising this pulp, which is rich in fat, proteins and minerals, as a base for the preparation of soups or other suitable products, is being explored.

6.24 Survey of the quality of soft drinks

Some preliminary work was done in order to get an idea of the nature of soft drinks which are being retailed on a large scale in different parts of the country. Most of the samples collected locally, contained saccharin, while only a few contained sugar. While most of the samples contained

permissible colours, added singly or in combination, a few showed the presence of unpermitted colours. The majority of the samples gave positive test for the presence of *E. coli*. The survey is now being extended to other regions.

6.25 Postgraduate teaching

Twelve students were admitted to the First Year Class of the Two Year Postgraduate Associateship Course (1961-63 Session).

6.26 Ad-hoc training

Two nominees from the Regional Research Laboratory, Jorhat, on deputation for a period of six months, were working in the Division.

Methods of dehydration of fruit and vegetable and estimation of carotene were demonstrated to 12 students from Home Science College, Coimbatore.

Two students from the Department of Chemical Technology, Bombay University, were given training for a period of one week.

6.27 Fruit Products Order

6431 samples of different categories of fruit and vegetable products were analysed and reported upon.

7. Arecanut Technology Unit

7.1 Storage of ripe areca fruits

7.1.1. Preservative steeping storage: The preservative steeping storage of ripe areca fruits was continued over a second year. Changes in acidity and preservative levels in relation to containers were studied in detail. Packing of containers with fruits was found to retard the rate of loss of sulphur dioxide. Maintenance of good levels even at the end of four to six months were thus obtained in seepage proof containers with loose lids and the fruits remained as good as new. With lined mud pots and cement tanks, the sulphur dioxide level came down to 100 p.p.m. within a month, with consequent mild yeast infection at the surface. These containers were, however, successfully used for storage of fruits for over six months with periodical addition of metabisulphite and acid.

Field trials of the preservative steeping storage were also undertaken for a second year at Pudukudy using different containers with essentially the same results as obtained in the laboratory. Severe summer conditions resulted in greater loss of preservative and liquid levels. With attention at first, second and fourth month, the storage is continuing in its sixth month.

5,000 fruits of 1960-61 harvest stored for eight to ten months, were evaluated by independent officers of the West Bengal Agricultural Service. The fruits, pre-packed in polythene bags after a transport of over 1,000 miles for a fortnight, were reported to be as good as new in appearance and chewing quality and obtained the maximum price. The chemical analysis of the nuts from the stored fruits was nearly the same as those from fresh fruits.

10,000 fruits of the 1961-62 season stored for four months in the field trial were also evaluated and sold. All the judges accepted the appearance of the fruit as good as fresh and majority of them accepted the chewing quality of the nut, though some preferred the *neetadaka* (from traditional water steeping) with its characteristic foul smell! The price obtained for the stored product was 100 per cent higher than the cost price.

Potassium metabisulphite (KMS), benzoate and sorbate were absorbed from steeping solutions at a fast rate by the husk, reaching equilibrium in the course of 5-10 days. The desorption of sulphur dioxide was also rapid and the rate was higher at higher initial levels. A steeping solution concentration of 0.5 per cent KMS was found to be optimal, which gave an initial sulphur dioxide level of around 1,400 p.p.m. in husk and around 150 p.p.m. in the nut. Depending on the magnitude and nature of incipient infection, the fruits remained free from infection when pre-packed for

periods ranging from 30 to 200 days. However, a second steeping treatment of fruits showing early infection gave prolonged successful storage for over 90 days.

7.1.2 Use of gaseous fumigants :

(In collaboration with Infestation Control and Pesticides Division)

The use of gaseous fumigants on metabisulphite incorporated fruits was studied. The gaseous fumigants in most cases extended the storage life by three to six times. The best results were obtained with methyl bromide, chloropicrin and ethyl formate. As with sulphur dioxide, a repeat treatment at the time when infection just starts, prolonged the subsequent storage over long periods extending to over 140 days.

7.2 Microbiology of fresh and stored areca fruits

Examination of over 360 samples of fruits from six regions showed infection of skin 87 per cent, husk 39-57 per cent and nut 34-46 per cent. The normal microflora were found to be aerobic spore-forming bacteria and the fungi, *Aspergillus*, *Penicillium* and *Mucor* from external sources and the pathogens, *Thielaviopsis* and *Subrahmanella* (new genus). The predominant organism from inside the nut was a short bacterial rod. The normal load of the fruits varied, the maximum being 800×10^2 per g. in skin; 167×10^2 per g. in husk and 13×10^2 per g. in the nut.

The microbiological evaluation of the stored areca fruits generally showed that the steeping solution was free from bacteria, while surface yeasts, *Candida sp.*, were found whenever the level of sulphur dioxide was below 200 p.p.m. In 25 per cent of the cases examined, the skin and husk gave sparse growth of bacteria, while the nuts were in most cases free. In all cases, the fruit and nut were rated as good as fresh fruit and there was no bacterial spoilage as obtained with traditional water steeping. While continued contact with bacteriostatic agents, such as benzoate and sorbate at low levels, 0.1 to 0.2 per cent, killed the yeasts and long bacterial rod in two to three weeks, the short rod isolate was only arrested in growth even at the end of twenty weeks. Among the gaseous fumigants, chloropicrin and methyl bromide were effective against bacteria while ethyl formate was effective against fungi.

7.3 Processing and drying

Continuing the work on the use of the boiler-cum-drier for processing green nuts reported last year, a field trial was undertaken at the Regional Arecanut Research Station, Hirehalli. A total of 600 kg. of raw material from six grower-processors was processed to produce different types, *churs*, *podis* and *batladike*. From each batch, a portion was processed by the traditional sun-drying. In the opinion of the processors, the product from the boiler-cum-drier was comparable in quality, yield and market value to the best sun dried product. From the data collected, it

was seen that, at maximum tray loads of 4-8 kg., and at drying temperatures of less than 100°C and depending on size of the cut nuts, the drying could be completed in 6-8 hours compared to sun-drying in single layers for two days. The preliminary estimation showed a small increase in the cost of processing in the mechanical drier but the many advantages were considered worth the extra cost by the grower-processors.

Drying of ripe areca fruits for producing *chali* nuts was continued for a second season. The process was slightly modified to increase gradually, the inlet temperature to 60°C towards the end, which increased the drying rate at the end without affecting the colour of the nut. The results obtained confirmed the earlier observations and clearly indicated that the percentage of defective nuts in the final product was related to the season of harvest—possibly the physiological state of the fruit. These correlations were also seen in the results from traditional sun-drying at the source.

A study of the quality characteristics and their relation to price was studied at Mangalore and, based on this, a tentative scoring of maximum deduction value for defects was formulated. The principal quality characteristics related to the moisture content, inside structure, size, colour, freedom from fungus and the percentage of mature or overmature nuts. The product from the Through flow drier was evaluated by this scoring and the actual auctioned price was found to have a close inverse relationship to the total deduction score. The study will be continued to evolve quality grade specifications.

7.4 Storage of final products

Equilibrium relative humidity (ERH) studies were continued with further samples of dried whole, cut and processed types at different moisture levels.

Storage problems of scented *supari* were studied over an extended period of six months at three centres, with varying humidity and temperature conditions. Packings of cellophane in polythene, followed by glassine in polythene, gave the best results with reference to appearance, crispness flavour and taste. In areas of high humidity, use of sorbate had a beneficial effect on the control of mould growth. The results are being followed with field trials with bigger batches, and covering more centres.

7.5 Utilization of by-products

(In collaboration with Fruit Technology and Packaging and Containers Divisions)

Optimum conditions for pulping areca husk by the soda process were found to be as follows: a bath ratio of 1.5, 17.5 per cent total alkali, 170°C and two to three hours cooking. The yield of pulp was 52 per cent—56 per cent which, after beating for 1½ hours, gave a smooth buff coloured paper having reasonable breaking, tear and burst strengths. The bleachability of the pulp was poor. The neutral sodium sulphite

cook was also tried and gave a light coloured pulp with a high yield of 65 per cent.

Banana pseudostem, being available in the same area as areca husk, was studied as a possible source of high strength pulp for improving the areca husk pulp. Satisfactory pulp was obtained from banana stem when the fibre was prepared by preliminary extraction of starch, gums, mucilage etc., from the stem. The conditions for soda cook were: a bath ratio of 1:4, total chemicals; temperature, 170°C and digestion for 4 hours. The yield of the pulp was 48 per cent which, after further washing and beating, gave smooth paper of very high strength properties, though the pulp yield was much reduced. This pulp, when mixed with areca husk pulp at 25 per cent level, yielded a paper whose strength properties were nearly the same as those of ordinary kraft paper. As both areca husk and banana stem are bulky materials, simplified pulping methods adaptable at village level, are under study.

7.6 Chemistry of arecanut

The principal components contributing to taste of arecanut are the polyphenols. The different market varieties differ in their maturity and polyphenol contents. The astringent taste of different types and varieties varies considerably and likely depends not only on the total tannins but also on their molecular size distribution conditioned by the oxidation and condensation of the monomers. An extensive study of the polyphenols at different maturities and after different processing operations has been started.

A further 103 samples of fresh and processed arecanuts were analysed for detailed composition in connection with continuing studies on: (i) maturity and composition, (ii) composition of cultivators and nuts from different regions, (iii) changes during processing and storage and (iv) genuine and market samples for drawing up purity and quality grade standards.

8. Meat and Fish Technology

8.1 Baby food from meat

Investigations to improve the products already prepared, and to evolve new formulations, were undertaken. The improvement in the physical appearance (consistency) of the product could be achieved by suitably adjusting the total solids content (18-22 per cent) and by incorporation of starch, salt, skim milk powder in small quantities in the formulations. Processing the cans of 301×206 size for 60 minutes, at 10 lb. steam pressure was found to be adequate. Blends with vegetables *i.e.*, carrots, beet-root, beans, onions, cauliflower etc., are being developed. Further work on developing products from poultry, suitable to Indian tastes is in progress.

8.2 Meat powder

In preliminary experiments on the preparation of a bland, stable meat powder of low fat content and high nutritional value, a roller-dried meat powder has been prepared with approximately a protein content of 80 per cent and a fat content of about 10-12 per cent.

8.3 Studies on eggs

8.3.1 *Changes in ovomucin in thick and thin white:*

Work on the make-up of the polysaccharide portion of ovomucin isolated from thick and thin white from eggs stored for 1, 7, 15 and 30 days, has revealed galactose, mannose and an amino sugar which has been identified, by re-chromatographing the ninhydrin stained amino sugar spot and identifying the pentose, as glucosamine. To find out whether there is quantitative difference in the polysaccharide make-up, thin white from eggs stored for 1, 7, 15, and 30 days has been diluted to 80 per cent alcohol-concentration, the clear supernatant concentrated and subjected to estimation of reducing sugar, hexosamine, both free and acetylated hexosamine by chromatography.

The presence of glucose only was recorded by chromatography. The extracts were also +ve to Ehrlich reagent, both before and after acetylation. The Ehrlich test was negative after the extract was partitioned on Dowex-50. The positive results obtained for the presence of hexosamine, free as well as acetylated, is due to some interaction between the glucose and the basic amino acids in the unfractionated extract.

8.3.2 Duck eggs: Systematic analysis of duck eggs, regarding proximate composition, composition in terms of characteristic proteins and other physical quality attributes like yolk and albumin index, vitamins, etc., has been started.

8.4 Physico-chemical measurements of goat and sheep muscle

With a view to improving the quality of meat, pH, buffering capacity, percentage transmission of muscle pigments, loose-water number (lw), water-binding capacity and soluble protein nitrogen were determined in the goat and sheep muscles. It is observed that goat muscle is more tough and dark coloured than sheep muscle. Also, the water-binding and water-holding capacity of this muscle are different from that of sheep muscle.

8.4.1 *Changes in sheep muscle during storage at room temperature:*

In many of the cities, the carcasses of animals are usually hung for about 15 hours (overnight storage) after slaughter of animals. Meat sold to the public is generally stored for 15-24 hours at room temperature. The object of the present work was to observe the changes taking place in meat during this storage. The results indicate that considerable spoilage occurs in meat that is stored for such long periods. Initial pH of muscle was 6.5 and this decreased to 5.7 during post-rigor changes. The pH then increased from 5.7 to 6.1 when the meat was stored for 20 hours, thereby suggesting breakdown of muscle proteins resulting in the formation of ammonia and amines. Significant increase in α -amino nitrogen, soluble protein nitrogen and bacterial count was observed during this storage. The blooming red colour of meat also faded as shown by percentage transmission which increased from initial value of 64 to 75. In this connection, a simple method has been evolved to measure the colour of pigments in meat.

These findings show that, contrary to recommendations, fresh mutton is not sold to the public. Further work is in progress to determine the minimum period necessary for hanging the carcasses to effect partial tenderization.

8.5 Refrigerated storage of dressed poultry

Studies on the shelf-life of country breeds of poultry in refrigerated storage and on the possibilities of enhancing the shelf-life, have been started in view of the importance of the work to poultry marketing as well as in view of the interest evinced by the poultry committee of the I.C.A.R.

8.6 Preparation of deodourized fish flour from oil-sardine on a semi-pilot plant scale

Oil-sardine (5,000 lb.) were eviscerated, cooked, pressed and dried to a moisture content of about 5 per cent. The dried material was coarsely powdered before extracting it with 95 per cent ethyl alcohol. Twelve extractions with alcohol were carried out per batch to obtain deodourized fish flour.

It was observed that steam-cooking of sardines and efficient drying (within 4-5 hours) of cooked and pressed sardines, yield better quality

finished product from bacteriological viewpoint. Sardines of low fat content can be dried without subjecting them to cooking and pressing.

8.6.1 Shelf-life of fish flour: The product packed in sealed cans was stored at 40°C for 12 months. No change in colour of the product was observed. There was no development of rancidity and decrease in pepsin digestibility.

Recipes like vegetable curries, cutlets, chappaties and rice preparations containing about 10-20 per cent of fish flour have been prepared and found to be quite acceptable.

8.7 Fish protein enriched corn starch

A simple process has been developed which indicates that fat in lean fish could be retained without causing significant off-flavour due to oxidation of fat. Muscle portion and corn starch are blended in the ratio of 3:1 using suitable quantity of vanilla flavour. The blend is steam-sterilized, dried to 5 per cent moisture content and finely powdered. This product can also be prepared in the form of thin shining flakes by using drum-dryer. The protein content of the product is about 40 per cent and could be used to supplement foods deficient in protein.

8.8 Fish flour from Bombay duck (Bombil)

(In collaboration with Regional Research Stations Division)

Preliminary work on Bombay duck has been carried out with a view to developing an alternate source to sardine to prepare fish flour suitable for human consumption.

8.9 A new two-dimensional method of estimating amino acids

Using descending paper chromatographic method, the first run is made with butanol-acetic acid-water on Whatman filter paper no. 54 and the second run with 2-butanol containing 3 per cent ammonia. The amino acids separate quite distinctly by this method and the values estimated by this method compared with the values obtained by microbiological method.

8.10 Studies of cold storage of fresh water fish

Effect of pre-chilling of fish on retention of adenosine triphosphate content: The importance of cooling fresh fish to ice temperature in order to minimise its spoilage is well established, and hence the time taken for the fish to cool from 20-25°C to about 0°C is of great importance. With crushed ice, the temperature inside the centre of particularly big fish will be reached after a long time because of inefficient cooling due to air-gap in between the fish and ice and also due to the inadequate quantity of ice used in commercial practice. In case of pre-

chilling with ice-cold water (33°F) containing some ice, such a difficulty is overcome, with the result that, initial cooling of fish is brought down much faster by this method. Fish so cooled took considerably longer time to come out of rigor. Since rigor is closely connected with adenosine triphosphate content, attempts were made to determine ATP content of fish given two different treatments. The results indicate beneficial effect of pre-chilling the fish on retention of adenosine triphosphate. Further detailed work is in progress.

8.11 Fish hydrolysates

8.11.1 Preparation: Fresh water fish (*Barbus dubious*) was handled in 40 kg. batches under conditions designed to obtain different amounts of proteolytic products in the hydrolysates. The hydrolysates were obtained as powder by vacuum drying.

Three typical hydrolysates obtained were, in increasing order of hydrolysis, comparatively rich in (a) proteose-peptone (69.96 per cent), (b) peptone (57.79 per cent), and (c) sub-peptone (60.89 per cent). The first two types were obtained by short-time hydrolysis, while the third by long duration hydrolysis.

8.11.2 Biological evaluation: Growth rate of young weanling rats and weight response of protein-depleted adult rats have been determined by incorporating the 3 hydrolysates as the sole source of nitrogen in otherwise adequate experimental diets. It was found that the hydrolysate obtained after a long-term digestion was the best of the three hydrolysates, while the two typical short-time digests were not significantly different in their nutritive value.

8.11.3 Microbiological evaluation: The suitability of fish peptones (hydrolysates) prepared as above for the growth of certain selected cultures of microorganisms (including fastidious types) are being studied. The growth rates in the three experimental batches of fish peptones (hydrolysates) have been compared with those of (i) Difco bacto-peptone, (ii) Difco bacto-proteose peptone, (iii) Paul-Lewis bacto-peptone, and (iv) Difco bacto-tyrptone. The effects of additions of known concentrations of glucose, yeast-meat extracts to the experimental peptone media on the growth of micro-organisms have been studied. The results obtained so far indicate that, with the addition of yeast-meat extract, fish peptones (hydrolysates) promote good bacterial growth. Cultures grown in fish peptone water have given satisfactory indole and methyl-red reactions. The sensitivity limits to antibiotics of *micro-coccus aureus* (509 CFTRI) against penicillin G and aureomycin in media using Difco and fish peptones are more or less equal. Further work is in progress for a complete evaluation of fish peptones for microbiological work.

8.12 Ready-to-serve cook fish paste

A method has been formulated to prepare ready-to-serve cook fish paste with cooked tapioca/potato from (a) fresh mackerel, (b) sun-dried and salt-cured mackerel, (c) fresh sardines and (d) (fresh water fish) *Barbus carnaticus*. Incorporation of starchy materials minimised the fishy flavour of the product. Products like this enable the utilization of inferior types of fish which otherwise will be wasted.

8.13 Canning of sardine and mackerel in oil

The new technique of preventing water-oil emulsion in canned fish as developed in this laboratory was demonstrated to Messrs Malabar Fish Canning Co., Cochin. The fish were canned in rectangular and oval cans that were made available to us by the firm. The fish after evisceration cleaning and brining, were packed in containers with belly side up, so that silvery skin of the fish was uniformly visible. After the cans were accommodated in racks, the latter were locked and left inverted in steam retorts till almost all the free water from fish was removed. The cans were removed from the rack, filled with hot refined oil, sealed and steam-retorted till the bones got softened. By following this method, initial drying and frying of fish is eliminated thereby considerably saving on cost.

8.14 Refining of crude commercial sardine oil

8.14.1 Work on the purification of commercial sardine oil which was started at Mangalore sub-station, was continued on a semi-pilot plant scale at Mysore. Crude oils with 6.0, 9.4, 12.5 and 20 per cent FFA expressed as oleic acid, with obnoxious odour and dark colour, have been handled in 30 kg. experimental batches and refined to FFA of about 0.5 per cent, to natural sardine oil odour and to light yellowish brown colour. A procedure for refining has been arrived at on the basis of these experiments. The main steps consist of steaming of crude oil, alkali treatment, removal of soap and centrifugation to get the refined oil.

8.15 Proximate composition of frog leg muscle

Frogs of the two edible species, *Rana hexadactyla* and *Rana tigrina* were analysed for their proximate composition. The muscle portion of rear legs was used for analysis work. The experiments on frog breeding have been undertaken at Krishnarajasagar Fisheries Research Station. The first round of experiments have shown that the females of *Rana tigrina* spawn profusely by administering homoplastic pituitary injections.

8.16 Deodourisation of residual fish flavour from refrigerated vans

The problem of removing the residual fish odour from refrigerated railway vans that are at present being used to carry fish from fishing centres

to important cities, was referred to our Institute by the Railway Board. The idea is that the vans used for fish transportation could be utilized for transportation of other perishable materials. Preliminary trials have been conducted.

8.17 C.F.T.R.I. Fisheries Research Sub-station, Mangalore

8.17.1 *Partial de-odourisation of crude sardine oil:* Though the physical and chemical characteristics of the refined sardine oil were very much superior to the crude oil, yet it had rancid smell apart from the fishy smell. The combined treatment of citric acid and potassium metabisulphite or citric acid and sodium hydrosulphite, not only removed the foreign odours from the oil, but also reduced the fishy smell.

8.17.2 *Comparative effect of certain essential oils on the keeping quality of shrimps both at room temperature as well as under refrigerated conditions:* By giving the cinnamon oil dip treatment, the prawns could be kept in edible condition, about 4-6 hours more than the untreated sample at room temperature. The beneficial effect of the cinnamon oil has been observed both in case of beheaded prawn as well as prawn muscle (with no shell and head). The preservative effect of cinnamon oil is very much pronounced under refrigerated conditions than at room temperature, which is also the observed fact in case of antibiotics and chemicals. Further, the small quantity of cinnamon oil used for treatment (4 ml. cinnamon oil per litre distilled water) to the prawn, leaves behind a pleasing smell. The cost of preservative is small and the treatment is non-toxic unlike antibiotics and chemicals.

8.17.3 *Rapid chemical assessment of the quality of shrimp by simplified catechol ferric chloride method:* It is reported earlier, that different phases of quality of shrimp during the progressive spoilage can be evaluated by the catechol-ferric chloride method using Lumetron colorimeter. The method is being tested in several varieties of prawn available in Mangalore market to find out its limitations.

8.17.4 *Utilization of squilla and prawns head:* The cooked material was pressed in hand-driven screw press, when the pressed cake had about 35-40 per cent water in it. This was just spread on coir mat to dry in the sun. The squilla powder had a protein content of 40.3 per cent, calcium 6.1 per cent, phosphorus 7.5 per cent and fat 1.1 per cent, while the prawn head powder contained 40.2 per cent protein, 5.7 per cent calcium and 4.5 per cent phosphorus. Both these materials can conveniently be used as poultry feed.

9. Microbiology and Sanitation

9.1 Fermentation studies

9.1.1 Preparation and use of pectic enzymes from *A. aureus*: Pectolytic enzyme has been prepared by growing *Aspergillus aureus* on rice bran and the enzyme is obtained in two forms, viz., (i) mouldy bran powder (MB) dried with acetone and (ii) crude enzyme powder (CEP). Clarification of fruit juices, such as lime and grape juice, extraction of clear fruit juices from fruit pulps such as guava, banana, papaya and mango (where extraction of clear juice is difficult in the normal course) have been attempted with the help of this enzyme. In addition, usefulness of this enzyme in the lye-peeling of orange segments and extraction of juice from tamarind pulp has been investigated. The results obtained show that it is possible to get clear juices from all the fruits examined retaining the delicate original flavour of the respective fruits. Particular mention can be made of the fact that guava fruit juice retained as much as 210 mg./100 ml. of ascorbic acid at the end of a storage period of 3 months. The enzyme preparation was found to be as active as the foreign preparation.

With a view to selecting a suitable strain and standardising optimum conditions for maximum production of pectolytic enzymes, several fungi isolated from rotting fruits were isolated and their ability to produce pectolytic enzymes on supplying different sources of carbon and nitrogen was studied. Among the carbon sources studied, glucose gave maximum pectolytic activity when *Aspergillus aureus* was the organism. Starch, maltose, fructose and sucrose came next in order. In the case of *Penicillium expansum*, sucrose was found to be the best carbon source, followed by glucose and pectin. As regards the source of nitrogen, *Aspergillus aureus* gave good yields of the enzyme with both organic and inorganic sources of nitrogen, the best being L-asparagine and ammonium nitrate, while *Penicillium expansum* gave good yields of the enzyme only with ammonium nitrate, the other organic sources of nitrogen being very poor in this respect.

In order to examine the possibility of an economical production of the enzyme, studies were undertaken to find the suitability of different agricultural by-products, such as rice and wheat bran, oilseed cakes and molasses, and appropriateness of stationary as well as shake cultures. The results with agricultural by-products showed that *A. aureus* gave higher enzyme activity than *Penicillium expansum* on all the media tested and that wheat bran was superior to rice bran in giving good yields of the enzyme. Between the stationary and the shake cultures, the performance of *P. expansum* was better in shake culture than in stationary culture,

while the enzyme production by *A. aureus* was almost identical in both the methods of culturing. The enzyme potency of the crude enzyme powder produced in this laboratory has been compared with the commercial enzymes and found to possess almost the same activity.

9.1.2 Amino-acid fermentation (lysine and valine): In the studies on the production of lysine by fermentation, it was observed that *Ustilago maydis*, maintained on sterilised corn cobs for 10 days, gave an increase in the lysine content of the brew only after 120 hours of growth. Work is in progress to determine whether mycelial autolysis is necessary for maximum lysine yields. The effect of gibberellic acid on lysine production was studied and the results showed that gibberellic acid at 1-5 p.p.m. of the fermentation medium had no beneficial effect on the production of lysine.

Screening of bacteria that could produce different amino acids continued during the period under report. Over a thousand cultures have been examined of which one strain (No. 962) was obtained which could produce 3-4 mg. of a lanine /ml. Likewise, one strain (No. 219) was spotted for valine production. This organism was used to study the effect of different carbohydrate sources and also of different growth factors on valine production and the results showed that the medium containing 10 per cent glucose and 0.8 per cent urea, supplemented with corn steep liquor yeast extract and peptone meat extract at 0.2 per cent level, improved valine production. Studies on the effect of volume of the medium, aeration and metals on valine production by strain No. 219, indicated that 40 ml. medium in 250 ml. conical flasks, in a rotary shaker at 230 r.p.m. was optimum for valine production, but the presence of ferric iron and cobalt in 0.02 γ M/ml. concentration inhibited the accumulation of valine.

Cultural characteristics of strain No. 219 have been studied and the organism has been placed in the genus, *Aerobacter*, in the family *Enterobacteriaceae*.

Studies are in progress to get mutants of the two strains by exposure to ultra violet irradiation and to penicillin action and to get strains capable of giving good yields of valine and other essential amino acids.

9.1.3 Studies on amyloglucosidase from *Aspergillus niger*: Considering the advantages of enzymic hydrolysis of starch to get glucose, studies were undertaken to obtain good yields of amyloglucosidase from *Aspergillus niger*, which gives glucose directly from starch. As a preliminary, investigations were carried out on the relationship between the constituents of the medium and enzyme activity. The results obtained showed that the yield of the enzyme, amyloglucosidase, was directly correlated with the concentration of corn used and the maximum per cent of corn to be used was 10 per cent, above which the enzyme content would decrease. Maximum enzyme activity of 160 units/ml. is obtained by submerged fermentation in a rotary shaker for 120 hours. The enzyme

compares favourably with a commercial product, 'Diazyme', in enzyme activity under identical conditions of estimation. Chromatograms of the fermented broth revealed the presence of glucose, citric acid and other unidentified organic acid spots.

Inclusion of barley extract and caseinate has a beneficial effect on the enzyme production.

9.1.4 Studies on cellulose degradation: Cellulose was prepared by growing *Myrothecium verrucaria* and *Stachybotrys atra* under different cultural conditions with a view to using the enzyme for degrading cellulose in coconut cake. The activity of the enzyme was determined by determining the decrease in viscosity of carboxy-methyl cellulose solution. This was compared with that of 'Takamine cellulose'.

Similar studies were carried out with *Myrothecium verrucaria* by growing the organism on rice bran in trays at room temperature for a period of 8 days. The water extract of the mouldy bran was found to be active in reducing the viscosity of carboxy-methyl cellulose, but not so in bringing down the fibre content of rice bran. With a view to increasing the enzyme activity of the culture broths for insoluble substrates, such as native cellulose, cultures were grown in mineral broth with supplements of different concentrations of peptone yeast extract and B-complex vitamins. As a preliminary, the activity is determined by following up reduction in viscosity of carboxy-methyl cellulose solution. The results are given below:

Supplements		Time of flow in seconds
nil	...	48
0.2 per cent peptone	...	33
0.5 per cent peptone	...	33
1.0 per cent peptone	...	36
0.2 per cent yeast ext.	...	31
0.5 per cent yeast ext.	...	31
B-complex vitamins	...	50
Control (no enzyme)	...	82

Further work on the action of these enzyme preparations in reducing the fibre content of rice bran is in progress.

Cellulose prepared from *Myrothecium* and *Stachybotrys* was used to reduce the fibre content of coconut cake. The results have been found comparable in performance with those of takamine cellulose. *Stachybotrys* brings down the fibre content to a greater degree than *Myrothecium*.

Tray fermentation of the coconut cake obtained from Kraus-Moffei plant was attempted with a view to reducing fibre content by growing *Myrothecium* and *Stachybotrys*. Preliminary water extraction of the cake was found to be necessary to avoid bacterial growth. After one week's growth of *Myrothecium*, the fibre was reduced by 16 per cent.

9.1.5 Chemical treatment of coconut cake: Different solvents were tried for extraction of protein from coconut cake. The results showed that 4 per cent sodium chloride solution and N/20 sodium hydroxide gave maximum extraction of protein. Treatment of the cake with 1.5 and 2.0 N.H₂SO₄ both under aerobic and anaerobic conditions (at room temperature), showed that, under anaerobic conditions after a week's treatment, there was a slight increase in reducing sugar content of the acid cake suspension. Treatment of the cake with hydrochloric acid of strength varying from 1-5 per cent increased the fibre content of the cake expressed on dry weight. Acid treatment of the cake appeared to interfere with fibre degradation by *Myrothecium* when it was grown subsequently after washing it free of acid.

9.1.6 Studies on vinegar from malt extract by sub-merged fermentation: A systematic study was conducted to study the efficiency of different methods of vinegar production, *viz.*, (i) stationary or slow process, (ii) generator process, (iii) sub-merged shake culture process, and (iv) acetator process.

Conditions have been standardized for each of the methods. Of the four methods, the acetator process proved to be the best and production of vinegar is possible within 48 hours using a pre-activated culture, an air rate of 14.4 litres per hour and a 11 G. 4 sintered glass funnel for air distribution.

Chemical analysis of the vinegars produced under different methods of acetification has shown that except for the slightly higher ester value of vinegars produced under slow process, there does not seem to be any significant difference.

9.2 Food sanitation

In continuation of our earlier studies, 20 quarternary ammonium compounds and four samples of chlorine-based detergent sanitizers were examined for their effectiveness in eliminating *coliforms* from experimental plates. The results showed that, out of 20 quarternary ammonium compounds, only eleven had good sanitizing effect on both porcelain and metal plates, while five samples were effective only on porcelain plates and the remaining four were ineffective in the concentration tried. Chlorine-based detergents were uniformly effective in completely eliminating *coliforms* from plates.

A survey of bacterial population in the household plates showed that they were practically free from *coliforms*, while the plates in hotels always showed very high *coliform* counts. Preliminary examination of the cause of these high counts revealed that hands of servers carried heavy load of the organism. This is obviously due to poor hygienic sense among the workers, the only remedy being proper education of the workers.

In view of the fact that the sanitizers in the market are mostly patented formulations of foreign companies, attempts were made to evolve our own

formulations from indigenous raw materials. A mixture of soapnut powder, turmeric residue and grated soap was tried in different hotels and the results were suggestive of the fact that *coliform* count in the plates could be reduced considerably. In continuation of this study, it was found that acid activated clays in combination with chemical preservatives, such as potassium metabisulphite and citric acid, had appreciable sanitizing effect. Waste products, such as spent coffee powder, citrus peel powder, were also examined, but were found to be in-effective.

9.3 Studies on garlic

Studies on the suitability of packing material for gelatin capsules containing the dry mix of the concentrate of the precursor and allinase, showed that polyethylene laminated aluminium foil was the best packing material. The capsules wrapped in this material and stored at room temperature for 10 months, retained nearly 80 per cent of the antibacterial activity (ABA).

Work on the therapeutic property of the garlic capsules in the treatment of flatulence and dyspepsia was continued on 26 in-patients of K.R. Hospital, Mysore.

9.4 Studies on pepper

Studies were undertaken on different aspects of extraction of pepper, such as the effect of flaking of the rejections, effect of different methods of extraction (percolation and counter current extraction) and extraction at elevated temperatures ranging from 50-70°C. The results showed that the use of flaked pepper rejections and hot solvent, gives better yields of the bite principle. Similar studies carried out with black pepper showed that flaking was not practicable and extraction at elevated temperatures did not improve the yield. Studies on the effect of storage on the piperine content of the oleoresin showed that, over a period of 6 months at temperatures ranging from 80°F to 100°F and R.H. 90-98 per cent, the piperine content came down by 5 per cent in the oleoresin stored in glass containers, and 3 per cent when stored in aluminium bottles.

9.5 Studies on pickles

59 samples of lime, mango and gooseberry pickles prepared in the traditional way, were collected from homes and hotels and analysed for salt, acid and microorganisms associated with them. There was wide variation in respect of salt and acid concentrations in the samples. Out of 59 samples, 34 had salt concentration below 15 per cent. Incidence of spoilage in this group was about 92 per cent. Lime pickles, with salt concentrations at 15 per cent and above and acid at 3 per cent, mango and gooseberry pickles with 17 per cent salt and 2 per cent acid, were free from microbial spoilage. Similar trend was noticed in samples prepared in the traditional way in the laboratory. The method of preparation of pickles varies from place to place. Either due to faulty

procedure or the variation in the raw material, the critical concentration of salt and acid is not maintained and hence the pickles undergo spoilage. A preservative is therefore necessary to supplement the deficiency of salt or acid and preserve the pickle. A preservative emulsion containing acetic acid, orange peel oil, turmeric and mustard powder, was prepared using suitable emulsifiers. Acetic acid was used for its fungistatic action, orange peel oil for its inhibitory action on yeasts, turmeric powder to retain colour of the fruits and mustard powder to mask the flavour of acetic acid. Trials carried out on samples of pickles prepared in hotels and homes, indicated that the emulsion inhibited the microbial growth in all the samples irrespective of the concentration of salt and acid. Viable cells appeared to be absent in samples of pickles to which emulsion had been added.

It is found that the fruits can be cured in low strength brine using the emulsion by maintaining concentration of salt at 10 per cent level with 2 per cent acid, or at 6 per cent level with 4 per cent acid, in the brine containing the emulsion, microbial spoilage could be prevented.

9.6 Studies on pre-treatment of vegetables

Reducing the microbial load on vegetables would be an important step towards avoiding drastic conditions of processing and improving the palatability of the processed product. The method in vogue is to give a preliminary washing with water. This is not very helpful in reducing the load; on the other hand, the water itself might contribute some organisms. Washing the vegetables with detergent solutions, instead of plain water, helps a great deal in reducing the load. Systematic studies were carried out to test the efficacy of detergents, like *CDA-318*, *triton X-100* and *Iosan*, in concentrations recommended by the manufacturers in reducing the microbial load on vegetables. The results showed that *CDA-318* was not effective while, *triton X-100* and *Iosan* could reduce the microbial load on the vegetables appreciably.

9.7 Lye-peeling of mango ginger

Peeling of mango ginger is a time consuming process. Attempts were made to lye peel the mango ginger. Different strengths of lye and varying lengths of dipping time to completely remove the peel were studied. The data collected indicated that 25 per cent of lye with 2 minutes soaking could give a satisfactory product. The lye-peeled material is soaked over-night in 2 per cent citric acid and washed well to remove the acid.

9.8 Vegetable cheese

Attempts have been made to standardise conditions for the preparation of cheese from vegetable milks and vegetable protein isolates. Earlier work from this Institute has shown that cheese from groundnut milk using vegetable rennet, gives strong nutty flavour and tastes slightly bitter. Preliminary work carried out during the period under report on soya

bean milk, has shown that it is possible to get a cheese of fairly good texture; but the product has slight nutty flavour and taste. Studies are in progress to find out methods for eliminating the nutty flavour and taste. Use of groundnut protein isolate for the preparation of cheese has been explored. Preliminary results show that it is possible to get a cheese like product, with agreeable taste and flavour, although texture needs a lot of improvement. The main difficulty that is encountered, is the separation of extraneous fat from the product during pressing. Attempts are being made to work out conditions for preventing the fat from oozing out.

9.9 Studies on toxicity in groundnut and its products

Groundnut and its meal infected with *Aspergillus flavus* have been reported to be toxic to ducklings in foreign countries. In India, groundnut and its products are being used in large quantities in the preparation of protein rich foods. In this context, studies were undertaken to find out the incidence of this fungus on groundnut as well as its cake. A number of fungi have been isolated from raw peanut, processed peanut cake and peanut flour and spice powders. Out of these, three isolates appeared to be somewhat similar to *Aspergillus flavus*. Further studies are in progress to find out their toxicity.

9.10 Other activities

9.10.1 Preparation of sauce from fruit pulp: The pulp from fruits after the extraction of juice has little or no use. With the pulp as base, a sauce was prepared with spices and vinegar. The whole mass was cooked, a good blend of spices added and passed through a homogeniser. The product was comparable in flavour and taste with some of the popular foreign brands of sauce on the market.

9.10.2 Ginger sauce: Utilization of surplus ginger is a problem. Attempts were made to use ginger as a base in the preparation of ginger sauce. Juice from fresh ginger formed 30-40 per cent of the sauce. It had strong ginger flavour. Perhaps this might offer itself as one of the methods of preserving ginger in seasons of plenty.

9.10.3 Lectures and training: Over 25 lectures on general and food microbiology were delivered and over 10 practical classes conducted on general microbiology to the students of the Associateship course in fruit technology and a nominee of the Regional Research Laboratory, Jorhat was trained for a month in microbiological techniques.

9.10.4 Technical aid to industry: A number of samples drawn from the industry and also received from governmental organizations were suitably analysed for their microbiological aspects and advice given to improve them, where required. In addition, yeast and acetic cultures (mother vinegar) were supplied to 25 different parties and methods of preparation of vinegars, sauces, wines etc., were furnished to the interested parties.

10. Food Engineering

10.1 Pilot plants

10.1.1 Coconut processing: The pilot plant for processing coconut according to the *Krauss-Maffei* process was shifted from Tata Oil Mills, Ernakulam, to the Institute. The plant was worked for several batches. Difficulties in processing, particularly regarding the press, were conveyed to the plant manufacturers who have now supplied a new worm for the press for giving better efficiency and output. This is being fitted up and tried. A ring drier has been supplied recently as part of the plant which is under erection and test.

10.1.2 Protein project: Specifications for all the equipment required for setting up a plant at Bombay under the auspices of N.R.D.C. were drawn up. After collecting necessary design data for the groundnut wetting unit and kernel cooler, necessary designs were made. The wetting unit has been fabricated in our workshop and is now under test. Fabrication of the kernel cooler is nearing completion. The fabrication of a rotary vacuum filter and accessories including the protein extraction tank has been completed in our workshop and the same are under trials to test their efficiency and for minor modifications, if any. Instrumentation requirements were drawn up and necessary diagrams prepared. Lay-out drawings for the proposed plant at Bombay have been made with the help of a scale model. Dr S. S. Kalbag visited Germany, Denmark and U.K. along with a representative of Messrs Tatas and conducted performance tests on spray-dryers and centrifuges. Based on these tests, necessary equipments have been ordered for the project. This visit was also availed of to discuss the work relating to the *Krauss-Maffei* plant with the manufacturers. Some quantities of the protein isolate were produced in 100 lb. batches for use in animal feeding experiments and for trials by Messrs Tatas and other agencies.

The integrated process has also been utilised for extraction of protein from castor and sesame seeds. Work relating to this is in progress.

Arising out of the work in connection with the protein project, studies on the rate of separation of fat globules in groundnut dispersions prepared under various conditions of work, are in progress to correlate laboratory data with pilot plant and industrial centrifuges. Laboratory data have been collected for determination of the optimum filtration cycle. These data are being applied and tested on the horizontal vacuum filter made in our workshop. Studies are also being conducted on isolation of protein from oilseeds in non-aqueous media.

10.1.3 Protein hydrolysates: Several batches of sesame (*til*) cake were processed for isolation and hydrolysis of protein. This work was done in collaboration with Dr C. R. Krishnamurthy of C.D.R.I., Lucknow. The hydrolysate was concentrated and dried. Experiments were also done to improve the yields by directly hydrolysing the protein in the solvent extracted meal.

10.2 Solvent extraction studies

Studies have been made for direct one step extraction of groundnuts, soyabeans, safflower, mustard and sesame. The results are encouraging. Further work is in progress.

Isolation of groundnut protein for edible and non-edible uses from solvent extracted groundnut flour has been tried.

Differential settling studies on flaked, unextracted groundnut kernels and hexane-extracted groundnut flour are in progress.

Cold extraction of coconut oil using alcohol as the dehydrating agent and heptane as the extracting agent for oil, is being studied.

Laboratory studies on the continuous solvent extraction of raw rice bran, groundnut flakes and fresh coconut are being made. Arising out of the work on solvent extraction, the following studies have been made and further work is in progress: (a) design and construction of an air-separator and studies with the same for the purification of commercial rice bran and extracted rice bran and rice germs, (b) separation of protein rich materials from solvent extracted cakes by the froth-floatation method using different foaming agents and depressants, (c) analysis of samples of extracted rice bran received from various sources for determination of sand and silica and other oil cakes like corn-oil cake, (d) literature survey on solvent extraction, (e) erection of the Buss Solvent Extractor received from Switzerland through T.C.M. aid for conducting further studies on solvent extraction of various materials and (f) extraction of turmeric with hot alcohol for work on colourisation of *vanaspathi*.

10.3 Azeotropic drying and extraction studies on coconut kernel

Laboratory-scale experiments, using 500 g. to 1 kg. of the kernels were carried out to see the feasibility of utilization of the process in obtaining edible coconut meal with the least possible oil and moisture content. Half a dozen large-scale batches, using 5 kg. to 30 kg. charge were also carried out on the basis of results obtained in the bench-scale experiments. Use of different solvents and their merits were studied. Further work is in progress.

Studies on direct extraction of groundnut through conditioning to suitable moisture content and subsequent azeotropic drying and defatting as well as studies on the utilization of extracted groundnut and coconut cakes are in progress.

10.4 Additional items of work

Experiments have been done to study possible improvements in the process of making rice flakes. The necessary equipment for the roasting is being fabricated in our workshop.

Trials have also been carried out for standardisation of conditions in preparing soluble coffee using the continuous counter current extractor designed and fabricated at the Institute.

Based on the data collected on bench-scale experiments, an all-stainless steel hot preserves unit has been designed and constructed in our workshop. The unit has been used successfully in making a good quality preserve from ash gourds.

A plant obtained from Messrs Starcosa of West Germany, for processing of tubers into starch is under erection. Parts of this unit are being utilised in processing papaya for pectin and for production of tapioca chips for conversion into flour.

It is proposed to try certain large scale experiments on parboiling of paddy by a continuous process. A pilot plant unit for handling 600 lb. per hour of paddy, consisting of a soaking tank, a steaming chest and a vertical bed drier, has been designed. Fabrication of these items in the workshop is in progress. As soon as the fabrication is completed, trials will be conducted.

10.5 Pilot plant work

10.5.1 *Extraction of pectin from papaya:*

(In collaboration with Fruit Technology Division)

With a view to improving the process and mechanising as many operations as possible, the process is under constant study. A de-seeder and a cloth filter have been constructed and tried. Results are encouraging and further work is in progress.

10.5.2 *Production of mould diastase:*

(In collaboration with Microbiology Division)

An incubator-cum-drier and a trough mixer designed for this work, have been fabricated in our workshop. These are now under erection for testing.

10.5.3 *Accelerated freeze drier:*

(In collaboration with Processing Division)

Data on the performance of the 'accelerated freeze drier' (AFD) designed and constructed here have been collected. The results are very encouraging.

10.5.4 *Through-flow drier:*

(In collaboration with Arecanut Technology Unit)

The Through-flow drier for arecanuts (both raw and boiled) designed and fabricated last year has been found to work satisfactorily. Field

trials, which proved encouraging, were also conducted with this unit in one of the plantations. Based on the experience gained in these trials, a modified unit has been designed and is being fabricated for conducting extensive trials in various plantations in addition to work at the Institute.

10.5.5 Concentration of fruit juices:

(In collaboration with Regional Research Stations Division)

Work on concentration of fruit juices, such as orange and pineapple, is being organized.

10.5.6 Assistance for scaling-up processes: Necessary assistance has been rendered to various Divisions in the matter of equipment facilities for their trials. Particular mention may be made of the assistance rendered for scaling-up work on baker's yeast, production of tamarind concentrate and Indian multi-purpose food.

10.6 Design of equipment

Detailed designs for the following items of equipment have been made:

Wetting unit, kernel cooler and equilibration unit for the protein project.

Extraction unit for mould diastase.

Rotary air lock valve and raking device for soaking tank, and drive for steaming chest for studies on continuous parboiling of paddy.

Mechanically driven atomiser for spray-drying studies.

Modifications to the horizontal rotary vacuum filter.

Paddy roaster for making rice flakes.

Rotary filter and de-seeder for work in connection with the production of pectin from papaya.

Modified through-flow drier for arecanuts.

Pneumatic separator for rice bran and germs.

Densimetric classifier.

Double cone vacuum mixer-cum-drier.

Stainless steel drums for double drum dryer.

In addition to the above, a large number of designs for small and routine items of equipment such as tanks, jacketed vessels etc., required for laboratory and pilot plant studies, modification of existing equipment and lay-outs, proposals for proto-type equipment to be constructed at the Institute and outside, a large number of lay-outs and flow-sheets for processes, designs for furniture items etc., have been handled. Facilities for training of apprentices have also been provided.

10.7 Workshop—plant construction and maintenance

10.7.1 Equipment for the protein isolate project: Fabrication of the horizontal rotary vacuum filter with receiver and extraction tank,

has been completed and the equipment tested, for its performance. They are found to be quite satisfactory. Based on the tests, some minor modifications are being made to improve the working.

Wetting unit—fabrication completed; unit under test.

Kernel cooler—fabrication nearly complete.

10.7.2 *Equipment for work on continuous parboiling of paddy:*

(i) Soaking tank—fabrication completed; a rotary air lock valve and a rake are being added; (ii) steaming chest—fabrication in progress; (iii) vertical bed drier for paddy—fabrication with finned heaters completed; unit under test.

10.7.3 *Equipment for work on fungal diastase:* (i) U-trough mixer, (ii) incubator-cum-drier and (iii) extraction tanks—fabrication completed. The units are being assembled for test and further work is in progress.

10.7.4 *Equipment for work on pectin from papaya:* (i) Rotary cloth filter—fabrication completed; (ii) rotary de-seeder—fabrication completed; the units are under test for effecting improvements; (iii) aluminium storage tanks—fabrication completed.

10.7.5 *Other items of equipment completed:* (i) Storage tanks for solvents—100 glns. capacity—three (ii) rumbler, (iii) grinder for grinding glass, (iv) wax emulsion making for waxing of fruits—prototype unit and (v) grain silos with staging—three.

10.7.6 *Other fabrications in progress:* (i) Densimetric classifier (ii) double-cone-mixer-cum-drier and (iii) roaster for rice flakes.

In addition to the above, 50 items of work relating to fabrication of small equipment required for research, modifications of existing units etc., were handled in the workshop. Further a large number of items of routine maintenance works and carpentry work involving items of furniture and equipment, gadgets etc., were handled in the workshop.

10.7.7 *Other activities:* The workshop undertook training of a large number of trade apprentices as part of a programme of training sponsored by the C.S.I.R., in addition to providing in-plant training facilities for about a dozen trainees from colleges, polytechnics etc.

11. Packaging and Containers

11.1 Assessment of the efficiency of moisture proof biscuit cartons available in Indian market

A survey was undertaken to assess the efficiency of moisture proofness of the biscuit cartons used at present by the biscuit trade in India. These included a random survey of 25 different packages collected from the local market. The packages were studied for: (i) their method of packaging, (ii) quality of packaging materials used, (iii) dimensions of the package and (iv) moisture proofness.

The survey indicated that the packages were made of cartons using any one of the following packaging materials as over-wraps: (a) double waxed paper, (b) double waxed paper with closures dipped in wax, (c) poster paper dip-coated with wax, (d) wax paper with a further over-wrap of moisture proof cellulose film and (e) heat sealable laminated aluminium foil.

In order to assess the moisture proofness of the above types of packages, they were reproduced by using calcium chloride as the standard hygroscopic material. These cartons were subjected to accelerated storage conditions and were periodically weighed. The results of these studies indicate that even though the cartons over-wrapped with poster paper and dip-coated with wax were not very elegant, they were the most efficient of the packages examined. Laminated aluminium foil over-wrapped packages were next in order of efficiency. The rest of the packages were almost identical in their efficiency. Further studies are in progress in order to improve the efficiency of these cartons by suitable modifications.

11.2 Principles of box and crate construction

11.2.1 Collapsible and returnable container for bulk packaging: Three types of collapsible and returnable containers, like (i) using hinges with 90° freedom of movement and a simple device for closing, (ii) a box with detachable top and bottom and (iii) with angle iron, were designed and fabricated.

11.2.2 Nail holding power of wood under different climatic conditions: As reported earlier, coated nails have been found to give greater nail holding power to wood than uncoated nails. Studies were carried out on the newly designed, fabricated and calibrated equipment with six different nail coatings under four conditions of temperature and humidity. With this equipment, the energy required to withdraw the nail driven to 1" deep into the side grain of silver oak wood was studied.

The results so far obtained show that the coatings are not significantly effected by temperature and humidity conditions. As for as energy required to pull the nail is concerned, the coated nails are not far better than the plain nails. Further studies are in progress.

11.2.3 *A substitute for steel straps:* Making use of kraft paper, hemp and other types of fibres, attempts are being made to produce a substitute for steel strap. This strap could be used to strap corrugated boxes and other packages. The results are encouraging and further work is in progress.

11.3 Type of stitch and seam *vs* their functional properties

11.3.1 *The efficiency of seams and stitches to water vapour impermeability in laminated jute bags:* Of late, laminated jute bags are increasingly coming into use for packaging of products which are sensitive to moisture. At present, the bags are being stitched in different ways. Therefore, it was of interest to assess the efficiency of different types of seams to water vapour impermeability. Studies were carried out with a triple laminate of hessian-paper-polyethylene with asphalt as laminant. Bags with different types of seams and stitches under study, were got stitched in a factory at Madras and were filled with groundnut grits. The bags were stored at 100°F and 90 per cent R.H., exposing an experimental seam length of 12" and were periodically weighed to find out the moisture pick up by the material.

Preliminary results indicate that the water vapour permeability is high in bags in which the hessian fabric protrudes into the bag. There is no significant difference between the single and double stitches with regard to their water vapour permeability.

11.3.2 *Seams and stitches *vs* their mechanical strength:* Seams and stitches were tested for their mechanical strength.

Preliminary observations indicate that (i) the double stitch is stronger than the single stitch and (ii) the counter laid seam single and double sewn were the strongest ones.

Detailed studies have been planned to evaluate the efficiency of the closeness of the two stitch lines, the effect of the number of stitches and the optimum twist of the thread.

11.3.3 *Assessment of the efficiency of different seams and stitches to insect penetration:* (i) The laminate is not absolutely insect proof, (ii) insects could penetrate through counterlaid seam (single sewn), fold-over seam (single and double sewn) and seam on selvages, and (iii) it is difficult to draw conclusions on the efficiency of single and double stitches to insect penetration.

11.4 Assessment of journey hazards to packaged goods

11.4.1 *Survey of the packages handled by the railways:*

(In collaboration with Railway Board)

Railways are greatly interested to reduce the claims that they are paying at present. This involves the need for standardisation of packages used for various commodities and development of mechanical means of handling.

Studies have been undertaken to assess the different types of packages (their size, shape, weight and type of construction) that are used at present for different commodities. Studies have also been initiated in the first place at Mysore railway station and the preliminary trials for a month have indicated that most of the packages lie in the dimension range of: length 21" to 24"; breadth 15" to 18"; height 9" to 12" and a weight range of 10 kg. to 40 kg.

It is proposed to extend this type of investigation to other big commercial centres like Bombay, Calcutta, Madras etc., for one complete season. The data obtained may indicate a fair account of the present packages that are used for various commodities.

11.4.2 *Assessment of journey hazards:* In view of the bad handling and transport conditions in our country, attempts have been made to assess the likely shocks that the package would receive during transit by making use of PATRA multiple journey shock recorder. By this could be assessed (i) the drop height of the package and (ii) the equivalent drop height of other shocks on all faces of the package.

The equipment has been calibrated and is being sent by passenger train from Mysore to Bombay and back. After obtaining the data, it is proposed to send the journey shock recorder, along with a big consignment, in collaboration with interested firms.

11.5 Survey of the indigenous packaging materials

In the packaging of foods, the selection of proper kind of packaging material is an important factor. Hence studies have been undertaken to conduct a survey of the packaging materials produced in India with regard to their various physico-chemical properties. It is proposed to cover a wide variety of materials, like papers, paper boards, films, foils and laminates. In this connection, attempts have been made to procure samples from the leading manufacturers of these materials. It is hoped that this survey could give a fair indication of the present quality of material produced and used in our country. The results emerging out of this survey, would be valuable and could lead to the production of better quality materials.

11.6 Packaging and transportation of perishables

11.6.1 *Packaging and transport of fruits and vegetables in air-conditioned coaches:*

(In collaboration with Storage and Preservation Division)

As reported earlier, the transport of fruits and vegetables in air conditioned coaches were undertaken in collaboration with the Railway Board. The results of the studies have been communicated further work would be undertaken.

11.7 Pre-packaging studies on fresh produce

11.7.1 *Pre-packaging studies on brinjals:*

(Scheme sponsored by Messrs Union Carbide, India, Ltd.)

Studies on the pre-packaging of brinjals were undertaken, using flexible packaging films like polyethylene of different gauges and cellulose film (MST). Storage studies were carried out under four different conditions: (1) room conditions—75-80°F and 65-70 per cent R.H., (2) 78°F and 65-75 per cent R.H., (3) 47-50°F and 85-90 per cent R.H. and (4) 100°F and 90 per cent R.H.

About 0.5 kg of the vegetable was packaged in film bags of size 10" × 12" with a varying percentage of aeration from 0-1.27 per cent by making 2, 4, 6, 10, 20 and 30 circular vents. Before packaging, the vegetable was given the following pre-treatments: (1) dipping in wax emulsion containing fungicide, (2) washing in cold water and (3) removing most of the inedible stalk-end portion.

The studies indicate that, under all conditions of storage, (i) washing the produce before packaging has no beneficial effect, while the fungicide treatment reduces microbial spoilage considerably; (ii) the vegetable packaged in 100 gauge polyethylene film without aeration was in good condition as long as the carbondioxide build-up was within 5-6 per cent; and (iii) there was no appreciable change in vitamin C and reducing sugar contents during storage. Further studies are in progress.

11.8 Packaging and storage studies on soup powders

(In collaboration with Processing Division)

Five recipes of soup powders, *viz.*, split bean soup powder, cauliflower soup powder, onion soup powder, mixed vegetables soup powder and chicken soup powder, each containing more than one dried base, were used for packaging and storage studies, using packaging materials like polyethylene 300 and 500 gauge, cellulose film (MST), polycel, laminated aluminium foil and plain tin cans of 4 oz. capacity. Unit packs of 2-3 oz. were made and the packets were stored at (1) 100°F and 90 per cent R.H. and (2) 75°F and 70 per cent R.H.

The sample packs were withdrawn from the storage atmosphere periodically to assess their chemical and organoleptic evaluation.

Soup powders stored at 100°F, 90 per cent R.H., in polyethylene of 300 and 500 gauges were unacceptable at the end of 30 days, while the samples packed in polycel and cellulose film had a shelf-life of 60 days. Laminated aluminium foil was found to give the desired protection for more than 90 days. However, samples stored in tin cans were noticed to be inferior to those packed in aluminium foil for the same period.

The samples packed and stored at 75°F, 70 per cent R.H., in polyethylene (300 and 500 gauge), polycel and cellulose film had a shelf-life of 180 days, while the samples packed in aluminium foil kept well for 300 days as against tin cans for 240 days.

Under both the conditions of storage, the samples packed in laminated aluminium foil were found to be better than those in tin cans.

In general, there was an increase in free fatty acid content during storage and this was more pronounced in samples stored at 100°F and 90 per cent R.H.

11.9 Packaging studies on coffee

(In collaboration with Processing Division)

11.9.1 Raw coffee: In continuation of the earlier work, large-scale field studies on the bulk packaging of raw coffee seeds were undertaken using laminated jute bags. The seeds have kept well in these bags with negligible moisture pick up. Further studies are in progress.

11.9.2 Coffee powder: Packaging studies on coffee powder using flexible packaging materials, like low pressure polyethylene and cellulose film (MST) (double bag), have shown that these could give a shelf-life of about 10 days under room conditions, while coffee powder packed in laminated aluminium foil could give a shelf-life of 15 to 20 days when stored at 75°F and 70 per cent R.H.

Further work on the packing of the material in flexible containers under inert atmosphere is in progress.

11.10 Packaging of fresh fish and fish products

11.10.1 Insulated drip-proof aluminium fish containers for fresh fish:

(In collaboration with Engineering Division)

Using indigenously available insulating materials, drip-proof fish containers for the transport of iced fish has been designed and fabricated with aluminium alloy sheets. It is light in weight and can withstand journey hazards. It is proposed to take up actual field transport trials with these containers.

11.10.2 Insulated liners for fish baskets: Laboratory studies have shown that (i) a gunny cloth lined with perforated polyethylene film of 300-400 gauge and (ii) perforated polyethylene film (300-400

gauge) stitched in between two layers of gunny cloth, when used as a liner to bamboo baskets, would considerably retard the rate of melting of ice kept in these baskets. Preliminary field trials were carried out at Mangalore to find out the suitability of these liners for fish baskets. Pre-cooled fresh fish as well as fresh fish were used in the ratio of 1:1 fish to rice.

The results show that the fish was inedible in control baskets (without liners) after 14 hours, while fish in lined baskets, were edible even at the end of 26 hours. The fish that was in contact with polyethylene liner was adjudged the best. Further studies were extended to simulate the existing trade practice. It has been observed that, even though the ambient temperature went up to 118°F, the liners have shown definite advantage and it is necessary to carry out large scale trials.

11.10.3 *Packaging studies on fish flour:*

(In collaboration with Meat and Fish Technology Division)

Packaging studies of the defatted and deodourised fish flour were undertaken using flexible packaging materials. Preliminary studies have shown that the critical moisture content of the product is 10 per cent. Further work is in progress.

11.11 Entomological studies on packaging materials

11.11.1 *Studies on insect resistance of packaging materials:*

(In collaboration with Infestation Control and Pesticides Division)

In continuation of earlier work, studies on the insect resistance of packaging materials have been extended to other species and life stages of insects, under different conditions of temperature and humidity. Further work is in progress.

11.11.2 *Studies on the cockroach resistance of packaging materials:*

Cockroaches feed on a variety of packaging materials as well as packaged foods and have been found to attack adhesives based on starches and dextrines. Hence, protection of packaged foods against cockroach attack, assumes great importance.

Studies have been started to assess the cockroach resistance to varieties of packaging materials that are commonly used in food packaging, under different conditions of temperature and humidity. Preliminary screening results have shown that: (i) cellulose film, waxed papers, polyethylene lower gauges are easily susceptible to damage, (ii) aluminium foil with paper as the laminate is attacked, while aluminium foil as such is resistant although it is not cockroach proof, (iii) union kraft is more resistant than ordinary kraft and (iv) polycel is also damaged in relatively short period. Further studies are in progress.

11.12 Utilization of agricultural wastes

11.12.1 *Green and dried arecanut husk and banana pseudo-stem fibre pulp and paper:*

(In collaboration with Arecanut Technology Unit and Fruit Technology Division)

At present, large quantities of green and dried arecanut husk as well as banana pseudo-stem are not being used. Preliminary work showed that these wastes could be utilised for the preparation of pulp and paper. Paper made out of banana fibre pulp had high strength properties while that made out of arecanut husk fibre alone had low strength characteristics. Our studies have shown that a suitable blend of these two raw materials yields good quality paper.

11.12.2 *Utilization of paddy husk:* Studies were undertaken with paddy husk to find out the suitability of this material for converting into pulp. Preliminary work indicates that the paper obtained had low strength properties, but could be used as a filter along with other long fibre pulps. Further work is in progress.

11.13 Vacuum can soldering apparatus

A simple and small vacuum can soldering unit has been designed and made. This is to be used along with a vacuum pump, pressure gauge and a 6 volt transformer. The apparatus is compact and could be used on cans ranging from baby size to drums of giant size. With this, the leakages in the can seams or on any portion of the can before sealing could be detected.

12. Regional Research Stations

12.1 Regional Research Station—Bombay

The work of the Station was started at the premises of the College of Catering and Institutional Management, Andheri, Bombay-58, in May 1961.

12.1.1 Vegetable curd: To popularise the production of vegetable curd, a number of demonstrations were given for a period of about one year. As a result of this, a number of parties have shown keen interest in taking up its production.

12.1.2 Spin-pasteurizer: Large-scale demonstrations on the working of this equipment were given to a number of fruit preservation factories in the region and they have shown keen interest in adopting the machine in the processing of fruit products, like mango nectar, mango slices in syrup and orange segments.

12.1.3 Short courses in fruit and vegetable preservation: Short courses in fruit and vegetable preservation are being conducted and so far, over 50 students have been trained.

12.1.4 Quality control and F.P.O. analysis work: The quality control and F.P.O. analysis work was started on 1st May 1962. Over 200 samples including samples from consignments meant for export were analysed during May and June, 1962.

12.1.5 Canning of banana puree: Development of pink discolouration in the canned product has been the main problem of the canned product. The locally available *Harishal* variety and *Pachabale* variety grown in Mysore contain leuco-anthocyanins which, on processing, break down into leuco-compounds and anthocyanidin, resulting in the pink discolouration of the canned product. Among the various treatments studied, the following were found to be effective in overcoming the problem of discolouration: (1) pulping of the fruit in cold using ascorbic acid to prevent discolouration, (2) adjusting the pH of the pulp to 4.2, (3) filling the cold pulp into 1 lb. jam cans, (4) exhausting to a can centre temperature of 195°F and (5) sealing and processing of cans for a period of 10 minutes.

Trials on screening of varieties to find out their suitability for purposes of processing and studies on storage are in progress.

12.1.6 Waxing trials on tomatoes: Preliminary studies on the treatment of tomatoes with wax emulsion containing MH, showed that the treatment not only prolongs the storage life but also helps in uniform

ripening. Tomato ketchup prepared from treated tomatoes had better colour as compared to control. Further studies are in progress.

12.1.7 Varietal trials of mangoes: Although more than 400 varieties of mangoes are grown all over India, only a few varieties are used at present for processing. With a view to finding out the suitability of mangoes grown in and around Bombay for processing, varietal trials were carried out using five popular and important varieties. The products are under storage study.

12.1.8 Spoilage in vinegar: Investigations carried out on the spoilage of vinegar due to development of thick mat of film and reduction of acidity during storage, as reported by one of the factories, showed that the spoilage was due to inadequate pasteurization. Adequate pasteurization followed by packing in air tight bottles was found to overcome the spoilage. The factory was advised accordingly.

12.2 Regional Research Station—Nagpur

The Station, which was started at the premises of the Nagpur Orange Growers' Co-operative Association Ltd., Nagpur, has been shifted to 'Gole Bungalow', Nelson Square, Nagpur-1.

12.2.1 Varietal trials of tomatoes for canning as whole tomatoes, juice and puree: Disintegration of tomatoes during canning resulting in a mashy product, is the main problem in the canned products which are packed in large quantities for supply to Defence Forces. Juice prepared from the local varieties has also been reported to develop bitterness in the canned product. Seven varieties obtained from the Experimental Farms of the Agricultural College, Nagpur, were screened using Meyer's reagent for the presence of bitter principle, followed by a confirmatory precipitation test. It was found that all the varieties tested had no bitter principle. Canning trials carried out using these seven varieties, indicated that *Red Top* and *Chamali* varieties were best suited for the purpose, the breakage being 25 per cent and 18 per cent, respectively. Further, no breakage was observed when calcium chloride was added to the covering juice at the rate of 0.1 per cent.

In the case of tomato juice, in addition to carrying out varietal trials, the effect of maturity and the processing method on the development of bitterness were also investigated. Colour and flavour were found to be well preserved in *Pusa Rubi* and *Red Jacket* as compared to other varieties. Tests carried out for the presence of bitter principles on the tomatoes used in one of the factories, also gave negative results. It is, therefore, considered that the development of bitter taste might be more due to processing technique rather than varietal. Further studies are in progress.

The suitability of these different varieties for preparing tomato puree is also being studied.

12.2.2 Canning trials of cabbage: Development of pink colour has been a serious problem of the canned cabbages which are being canned in considerable quantity in different parts of the country for supply to Defence Forces. Screening tests carried out for the presence of leuco-anthocyanins on *Drumhead* and other varieties available locally, gave negative results. Various treatments given did not help in overcoming the pink discolouration. Detailed investigations on the problem are being continued at Regional Research Station—Trichur (please see under 12.3.1).

12.2.3 Investigations on the improvement of canning quality of cauliflower: Excessive disintegration and slight discolouration have been the main problems in the canned product which is canned in northern parts of the country for supply to Defence Forces. Preliminary investigations have shown that, among the various treatments studied, low temperature-long time blanching (at 160°F for 15 minutes), calcium treatment (1 per cent calcium chloride solution) under vacuum (25"—27") for four minutes followed by soaking in the same solution for another five minutes, improve the texture of the canned product slightly. Addition of 0.05 per cent citric acid and 0.03 per cent ascorbic acid to the covering brine improves the colour of the canned product. Further work is in progress.

12.2.4 Investigations on the prevention of disintegration in canned potatoes: *Chindwara* variety of potatoes available locally, suffer heavy disintegration during processing. Among the various treatments studied, calcium chloride treatment helped to check the disintegration to a slight extent but not completely. Since disintegration has been reported to be much less in potatoes which are slightly immature as compared to the fully mature, investigations are in progress to determine the specific gravity and canning quality of the potatoes at different stages of maturity and to fix the optimum specific gravity and/or other constants at which the local varieties of potatoes are suitable for canning and the range at which calcium chloride treatment is needed to prevent disintegration.

12.2.5 Integrated programme of work for orange industry: Out of nearly four lakh tonnes of oranges produced in different parts of the country, hardly 1 per cent is being used for processing. The rest is marketed as fresh fruit and nearly 30 per cent of it has been reported to go waste for one reason or the other. Therefore, an integrated programme of work is being carried out on different aspects.

12.2.6 Horticultural programme: Treatment of fruit using various growth regulators was initiated with a view to improving the fruit set, checking fruit drop, inducing delay in ripening and parthenocarp (which is required for purposes of canning the segments).

12.2.7 Commercial-scale waxing trials on oranges: Demonstrations on waxing of oranges were given at various places at Nagpur. About 14,000 fruits were waxed and sent to different markets *viz.*, Delhi, Bombay

and Madras and it was found that the waxed fruits in general fetched better price and remained attractive during transportation and marketing, while, at the same time, the spoilage was reduced considerably. The dealers have shown keen interest in adopting the process.

12.2.8 *Investigations on the processing technique of orange segments:* Orange segments in syrup have a considerable market in U.K. and at present have been the monopoly of Japan. In the canned product manufactured in the country during the last six or seven years, breakage of segments during canning due to deep seated seeds has been the main problem, although the canned product has better colour and flavour as compared with the product manufactured in Japan. The following treatments were, therefore, studied during pretreatment: (a) dipping of orange fruit in 1 per cent sodium orthophenyl phenate (SOPP) solution was found to reduce slightly the spoilage in oranges which are generally kept heaped in small lots for about six days and the physiological losses in weight of the fruit were the same as that of the control; (b) instead of the above method of curing which probably results in partial dehydration, preliminary investigations showed that partial dehydration of the segments prior to lye-peeling would overcome not only the need for storage of fruits for about six days but also lessen breakage in the canned product (4.3 to 8 per cent as compared to 18 per cent in control) resulting in a higher yield. Further investigations are in progress to standardize the method of dehydration and to confirm the results on a large scale.

12.2.9 *Orange juice concentrate and concentrate-based beverages:* In the concentrate-based squash, recently developed by one of the manufacturers in the area, it has been observed that, on dilution, it contains 40 per cent juice as compared to 7 per cent in the squash prepared by the usual method. Development of brown colour and off-flavour during storage of the product have been the main problems. Various treatments *e.g.*, storage at different temperatures, addition of ascorbic acid and/or sulphur dioxide, bulk storage in barrels using 1500 p.p.m. sulphur dioxide, replacement of sugar with glucose etc., are being investigated with a view to overcoming discolouration. Experiments are also under way to determine the minimum quantity of the preservative needed for preservation of the final product.

12.2.10 *Utilization of waste:* In the processing of oranges, nearly 30 per cent goes waste as peel and 25 per cent as pomace, which on dry weight basis contain 10-15 per cent and 20-25 per cent pectin respectively. In the process of extraction of pectin from orange pomace, it has been found that the blanched pomace, if passed through pulper with simultaneous addition of water, will be washed of most of the soluble solids present in it. The possibility of extraction of pectin using cation exchange resin (*Waso*), instead of the traditional method using HCl or citric acid, was investigated. It was found that one part of resin

is required to extract pectin from five parts of the pomace. Pectin extracts obtained by these different methods were also concentrated and drum-dried to eliminate the process of precipitation. The jelly prepared from the drum dried pectin had only a soft set.

Pectin present in the water extract of the pomace was precipitated using aluminium chloride and the possibilities of utilizing cation exchange resin *viz.*, *Ionac-150* (Foreign) or *Waso* resin (Indian), were investigated so that the use of alcohol could be eliminated. Preliminary results showed that for every five parts of the precipitate, nearly three parts of the resin (which of course could be regenerated) were required to remove the aluminium present in the precipitated aluminium pectinate. The spent resin could be separated from the pectin by centrifuging. The jelly prepared from the pectin obtained by these methods was slightly better as compared to drum-dried material. Further investigations on the quality of the pectin present in the pomace and peel in the mandarin oranges, changes that take place during processing and the grade of the pectin obtained by different methods are under study.

12.2.11 Operational research studies:

(In collaboration with Information, Statistics and Extension Services Division)

Please see **13.1.1.**

12.3 Regional Research Station—Trichur

The Station, which was started at the premises of the Darlco Cannings, Trichur, has been shifted to 'Krishnadas Niwas', Shoranoor Road, Thiruvambadi, Trichur.

12.3.1 Development of pink colour in canned cabbage: Continuing the investigations carried out at the Regional Research Station—Nagpur, preliminary screening of the local varieties gave negative results for leuco-anthocyanins. Various treatments like, addition of reducing or oxidising agents, changing of pH, canning in alkaline media, pre-soaking of the vegetables in salt solution, blanching, varying the processing time, etc., were found to have no significant effect. It was further observed that the pink colour in the canned product gradually decreased when kept exposed to air after opening the cans and the colour development started from the central core and gradually spread to the leaves. The colour development was still observed even if the cabbage was canned after removing the central core. The colour development was remarkably less in the case of outer leaves as compared to inner leaves when canned separately. When the cabbage was blanched, minced and then canned, the product was absolutely devoid of colour even after storage for three months. Similarly when cabbage was blanched, shredded and then canned, the product had good natural colour. Further work on the isolation and identification of colouring principle is also being carried out.

12.3.2 *Integrated programme of work for pineapple industry:*

(In collaboration with Storage and Preservation Division)

Development of pineapple industry during the last five years has been rather static owing to high cost of production as compared to other countries. With this in view, the following programme of work is being carried out.

(a) **HORTICULTURAL ASPECTS:** Experimental plots were laid out with a view to increasing the number of suckers per acre—7,000 to 17,000 as compared to 4,000 to 6,000 per acre planted in Kerala at present. The manurial and other requirements were also taken into consideration. The results of these investigations will be known in due course.

(b) **TREATMENT WITH GROWTH REGULATORS:** In order to space out the harvest period, treatment of plant with NAA, 2:4-D, MH and IAA in various concentrations for inducing or delaying flowering of pineapple, showed that NAA, under concentrations of 20 p.p.m. induced early flowering while, at higher concentrations, it had adverse effect. The fruit, however, was small in size in the treated plants as compared to control. The other hormones have not as yet given any conclusive results.

(c) **PRE-HARVEST HORMONE TREATMENT:** The fruits grown in Trichur area are oval in shape and are not of uniform size resulting in excessive preparation losses (60 per cent). In order to get cylindrical fruits, spraying with 200 p.p.m. of 2:4-D was found to increase considerably the length of the fruit, while spraying with 20 p.p.m. reduced the diameter. Further experiments are in progress to find out the optimum concentrations required.

(d) **WAX TREATMENT:** Waxing with 6 per cent wax emulsion or wax + TCNB prior to harvest in the month of November, was found to keep the fruits after harvest well for a period of 14-15 days as compared to six days in the case of untreated fruits. Fruits treated similarly and after harvest were despatched to different stations *viz.*, Bombay, Nagpur and Mysore, to study the effect of long distance transportation. The results are under compilation.

12.3.3 *Utilization of pineapple juice and cannery waste:* Pineapple juice, at present, is being produced far in excess of the requirement. Concentrate prepared from pineapple juice having 15°Brix and 0.5 per cent acidity concentrated four fold and cut-back with fresh juice (25 per cent of the weight of the concentrate) had a good colour and flavour. Addition of sugar to the juice or concentrate was found to enhance the flavour. The concentrated product may form a good beverage base for ready-to-serve drinks. Storage studies are in progress.

Pomace left after the extraction of juice is not being utilized. This waste material, after fermentation of 24 hours with actively fermenting yeast and addition of 0.1 per cent ammonium sulphate and 100 p.p.m.

sulphur dioxide, yielded 35 per cent juice when pressed in a basket press. Addition of a small quantity of sugar to pomace prior to fermentation was found necessary to get 4 per cent acetic acid in the final product. After completion of alcoholic fermentation and racking, good quality vinegar was prepared by using vinegar generator. The suitability of the wet pomace for use as cattle feed by drying and ensilaging is being investigated.

In the same way, good quality vinegar was prepared from the peel, and its suitability for cattle feed is also being studied.

12.3.4 Utilization of cashew apple: Nearly 2,50,000 tonnes of cashew apple produced annually go waste due to the acrid taste of the fruit. Cashew apple juice, however, is a rich source of ascorbic acid (170-236 mg./100 g.). It was found that cashew apple juice, after necessary treatment and blending with ginger extract, gave a refreshing beverage which had good flavour. Addition of coffee or tea extract or even pineapple juice was found to enhance the flavour. Concentration studies are being conducted with a view to preparing a beverage-base, rich in ascorbic acid content.

12.4 Regional Research Station—Lucknow

The Station started functioning during early May 1962 and is located at 10 Blunt Square, Lucknow. ■

12.5 Regional Research Stations—Gauhati, Kodur and Jadavpur

Preliminary survey is being carried out to start two main Regional Research Stations at Gauhati and Kodur respectively, and one sub-Station at Jadavpur, before 1963.

12.6 Technical aid to the industry

At the instance of the industry, a number of short term investigations were undertaken on the manufacturing problems and/or spoilage and the parties were advised suitably.

Technical advice was rendered to nearly 60 parties for establishing fruit and vegetable processing factories by way of providing schemes, blue prints and/or other technical details. The staff members of the different Regional Research Stations also gave on the spot technical assistance to different manufacturers for the preparation of fruit products, for overcoming the manufacturing problems and/or in the development of new products.

13. Information, Statistics and Extension Services

13.1 Operational research

(In collaboration with Regional Research Stations Division)

13.1.1 Pineapple processing: The detailed report of the work has already been submitted. The recommendations made were put into practice. It is now proposed (*i*) to follow it up by evaluating the effectiveness of the newer practices and (*ii*) carrying out similar studies in other factories.

13.1.2 Orange segment processing: A preliminary survey of the industries was made to find out the possibilities and to plan the work. Based on the work and depending on the season, an investigation was carried out at Nagpur Orange Growers' Association, Nagpur (NOGA). The main purpose of the programme of work was to find out problem areas in the production system where intensive studies would lead to increased operational efficiencies and result in a decrease in the cost of production.

The aspects covered in the study were as follows: (*a*) loss in the efficiency in turnover from workers due to incidence of quite a good number of inefficient persons among them, (*b*) size of the fruit and variation in the yield and (*c*) seasonal variation and its relation to the yield in output per unit input.

The study, though very limited in nature, revealed some interesting features. These are: (*a*) the weights of seeds and waste seem to increase with the increase in the size of the fruit, while the weight of peels is about the same, (*b*) with the increase in size of the fruit, the output of workers at peeling, de-segmenting and de-seeding would increase as the idle time in change over from one fruit to another is reduced for the same input of raw material, (*c*) the efficiency of the production system is lower as compared to the experimental lots where a set of able and efficient workers were requisitioned to do the work and (*d*) the output per unit of input is more in the period February-April than in the period October-December.

The foregoing results are tentative. Thus, to examine the effect of size of the fruit on the yield and waste, as also the effect of season on the quality and output of segments, further work on the following lines is planned: (*a*) production on 4 to 5 different sizes of the fruit in replications of at least 5 numbers to find out the size of the fruit which

would optimise production of segments, (b) classification of yield month-wise and examination of information from records for variation in the output per unit input during a year, between months and between years, in order to find out why, during a period, the yield is maximum and (c) collection of extensive snap readings on the time measurement of unit operations to set up work-load standards at these unit operations for stream-lining the production system for varying production targets, using fruits of different sizes.

13.1.3 Annotated bibliography: An annotated and selective bibliography on operational research statistics and management studies in food technology for the period 1950-60 has been completed. The purpose of the study is to provide the food technologists with the necessary information on the incidence of the extensive applications of the disciplines in question, for purposes of better planning and execution of research work and better utilization of results of research.

13.2 Statistical investigations

13.2.1 Survey on growth rate of school children:

(In collaboration with Dietetics Division)

The difficulty in getting even reasonably accurate estimates of the ages of children has been mentioned by a number of workers in India and abroad. Data on the chronology of human dentition have been provided (due to Logan and Kronfeld) in *Normal values in clinical medicine* by F. N. Sunderman and E. Boerner. In the survey carried out earlier by the Institute in Mysore City on over 3,000 school children belonging to 20 schools (selected to represent different localities and socio-economic groups), the ages of almost all the children were estimated according to Logan and Kronfeld standard. However, correct dates of birth were available for 796 boys and 744 girls only. From the two way frequency tables, it is found that the age estimated by the stage of dentition agrees completely with the true age in 34.5 per cent of the boys and 35.9 per cent of the girls. However, the age by dentition completely agrees or is in error by one year only in 81.2 per cent of the boys and 80.8 per cent of the girls respectively.

Further, it is found that both in the case of boys and girls, there is a perceptible tendency for over-estimation for the children upto 8-9 years and under-estimation for children above 8-9 years.

The results from the survey have shown that, under present Indian conditions, where it is difficult to get even reasonably accurate estimates of age from the parents, stage of eruption of teeth can be used for estimating the age of children. In view of the bias observed in the estimated ages, it appears desirable to collect data on the stage of dentition under Indian conditions for a large number of children at various ages (for whom information on correct dates of birth is available) for formulating the basis for estimation of age.

In the survey referred to above, the heights and weights were taken at intervals of approximately 4 months, beginning from the last week of February 1955, for all the children referred to earlier. Altogether 5 rounds of measurements were taken. For the first round, information on actual date of birth, height and weight was available for 718 boys and 755 girls only. Mean heights and weights were obtained for these children for different age groups. It would appear that in boys, the growth in terms of height is slack at the age 6-7 and again at the age 9-10. In girls, the slackness in growth appears to occur at the age 5-6 and 7-8. At the age group 12-13, the height appears to remain stationary for about a year in girls. Although the measurements were taken at 5 successive rounds, only 344 boys and 291 girls with correct dates of birth were present in the first four rounds. An examination of the mean heights, at successive rounds at each age group, did not reveal any appreciable spurt in growth either in boys or in girls. As regards weight, it appears that the period from November to March promotes larger gains in weight in both boys and girls than in other periods.

13.2.2 Assistance to research workers: The Division continued its assistance to the research workers by providing suitable designs for their experiments and by carrying out the statistical analysis of the data from such experiments.

The Division also gave technical advice to the Christian Medical College and Hospital, Vellore, in the feeding experiment with low cost protein food and Indian multi-purpose food.

13.2.3 Statistics of acreage, production, imports, exports etc.: Statistical data on the acreage and production of important fruits and vegetable products, figures of imports and exports of food articles etc., have been collected. The data are now being consolidated and cumulative record kept.

13.3 Extension work

13.3.1 Vegetable curd: Compilation of socio-economic data obtained through the questionnaire method in Lashkar Mohalla, Mysore, helped in planning suitably the programme of extension work for vegetable curds and in the production of visual aids to conform to the special needs of the area. Literature was prepared in Urdu for muslims whose awareness was the least: more attention was given to convincing women groups and the work slanted towards paying more attention to the low-income groups whose need for nutritious products of this type was the greatest.

Intensive extension work was started in September 1961 and is in progress. There was a short break in the work between December 1961 and March 1962 due to the onset of cold weather, during which period even the consumption of animal milk curd registers steep fall. The work comprised contacts with group leaders and heads; demonstrations on the use of the product in keeping with traditional methods; use of literature and audio-visual aids. Approach was made to make groups

realise the need for a product of this type and considerable emphasis was given to ensuring follow up work.

At Jyothinagar which is a colony of the Armed Reserve Police, a specialised approach of inducing consumer acceptance was attempted with the help of the official authorities. Home delivery of the curd to the members of the colony has also been arranged.

Twelve agencies in different parts of the country became interested in vegetable curd manufacturing enterprise, as a result of wide publicity given to the product by the Institute and Regional Research Stations. Details of processing, cost and availability of equipment were supplied to the parties. Contacts with the parties are being pursued to persuade them to take over the processes of production.

13.3.2 Indian multi-purpose food: Intensive extension work led to wider acceptance of the Indian multi-purpose food. The aim of the work was to make the school children and leaders connected with the school feeding programmes realise the full value and need of the food. The Government of Madras has now planned to extend the use of this food throughout the state and the pilot plant set up in Coimbatore for the manufacture of MPF, is supplying the requirements of the food to schools. A programme of extension work with the food for industrial canteens has been drawn up.

Liaison with the Food Department of the Govt. of India and contacts with Development Blocks, Vijyan Mandirs and other organisations were maintained through supply of literature etc., about this food. Plans are also under way for effecting closer liaison with these organisations, by way of meeting their needs for display materials, short-term exhibitions and exchange of visits.

13.4 Short courses, demonstration media and lectures

13.4.1 Short courses in fruit and vegetable preservation: Short courses including theory and practice in the fruit and vegetable preservation were given to the following organisations:

(i) MAHILA SAMAJ CO-OPERATIVE SOCIETY LTD., VIRAJPET

Forty members of the Mahila Samaj and employees of the B.D.O. and local housewives attended the course. As a result of this training, and the technical help rendered in planning and organization, a centre for fruit and vegetable preservation at Virajpet has been established.

(ii) TEACHERS' TRAINING COLLEGE, MYSORE

Thirty lady trainees of B.Ed. course were given training with a view to further propagating in their schools at least as a subject of extra-curricular activity.

(iii) GRAMA SEVIKAS TRAINING CENTRE, MANDYA

Forty Mukhya Sevikas drawn from different States and holding the final responsibility of the home-scale dissemination of techniques in the every day life were given training in the simplest and easily adoptable methods.

(iv) MANJESWAR BLOCK WOMEN'S COTTAGE INDUSTRIAL CO-OPERATIVE
SOCIETY LTD., PAIVALIKA, KERALA STATE

A group of 20 enlightened women of the area learnt with keen interest the modern but simple methods of preservation. Steps have already been taken by them to set up a training *cum* community canning centre. Necessary assistance for the centre has been provided.

13.4.2 Demonstration media: As a part of establishing closer contacts with the Governmental agencies engaged on extension work, blue-prints of demonstration van designed some years ago and having fittings of laboratory-type preparation benches, equipment needed for demonstrations and equipped with electricity generator, water-softener, refrigerator, baking unit, etc., were supplied against requests to the Governments of Maharashtra, Punjab, Himachal Pradesh, West Bengal and Andhra Pradesh, and also to the Central Ministry of Food. The van design is also provided with display windows and tourist-type folding furniture kits for the use of extension workers.

13.4.3 Special lectures: The members of the Division delivered eleven lectures dealing with different aspects of the activities of the Division to the students of the Associateship Course in Fruit Technology.

13.5 Technical aid to industry and public

13.5.1 Technical and general enquiries: During the year, 1,583 technical enquiries in addition to over 2,000 general enquiries, were answered. Replies to technical enquiries have been based on the published information about the research work at the Institute or data collected from literature in different fields of food services and technology. The break-up of these enquiries, subject-wise, is as follows:

1. Storage of grain	...	27
2. Storage of perishables	...	49
3. Fruit and vegetable technology	..	380
4. Microbiology	...	78
5. Biochemistry and nutrition	...	159
6. Dietetics	...	26
7. Containers and packaging	...	20
8. Tea and coffee	...	14
9. Cereal technology	...	143
10. Confectionery	...	22
11. Demonstrations and short-courses	...	39
12. Meat and meat products	...	4
13. Fish and fish products	...	11
14. Supplementary and substitute foods	...	179
15. Dairy products	...	44
16. Food additives	...	14
17. Literature and other information	...	365
18. Visitors for discussion and advice	...	9
Total		1,583

Besides, 334 technical enquiries and over 1,000 general enquiries were answered in Hindi and other regional languages.

13.5.2 Model schemes: Information about the pre-requisites as well as the model schemes for the setting up of food industries of different sizes, were continued to be supplied to the interested parties and this formed one of the regular features of the general enquiries attended to by the Division.

13.5.3 An investigation on "analysis of enquiries": A detailed study of the enquiries received by the Institute during a period of 27 months (May 1959-July 1961), was carried out to find the nature of source and kind of enquiries. This analytical approach was intended to serve as a basis for drawing up programmes of technical assistance and to have suitable technical literature for various types of enquiries.

Out of the total number of 4,027 technical enquiries handled during the particular period, it has been found that: (i) about 50 per cent related to the processes and products developed by the Institute, about 40 per cent to well-known processes and the rest were in respect of schemes, project reports etc., with a view to starting production units; (ii) larger number of enquiries were from Maharashtra, Madras, Uttar Pradesh and Mysore, and in the descending order reflecting, in some measure, on the progressiveness of the State; (iii) more than 60 per cent of the enquiries emanated from individuals as against 30 per cent each from manufacturers and merchants, and only 10 per cent from growers etc.; (iv) the number of enquiries on fruit and vegetable technology and on cereals was very great, followed by those on other subjects such as supplementary and substitute foods, bio-chemistry and nutrition, and on cereal technology, and very few on other topics; (v) the trend of enquiries counted in terms of source, nature etc., continued to be the same all through (month-wise).

13.5.4 Industrial liaison: Such of the parties as evinced keen interest in any process of the Institute or in any line of food technology were given full opportunity of personal contacts and discussions for working out details of production units.

13.6 Publication work

13.6.1 Regular: The publication of the three periodicals *Food Science* (monthly technical journal in *English*), *Ahara Vijnana* (quarterly popular *Kannada* journal), and *Khadya Vigyan* (quarterly popular *Hindi* journal) was continued according to schedule. Special efforts are being made to increase the readership of *Khadya Vigyan* and *Ahara Vijnana* by approaching Education, Health and Community Development Departments and village panchayats of the various States for the former and Mysore for the latter. Efforts have also been made to increase the number of advertisements for the three publications.

13.6.2 Books and monographs: SYMPOSIUM ON PROTEINS: pp. 456 + x, Cr. 4to (published on behalf of the C.S.I.R. Chemical Research Committee and Society of Biological Chemists, India), contains various facets of researches on proteins carried out in recent years by well known schools of research in India as presented in 72 papers).

13.6.3 Ad-hoc publications: The following *ad hoc* publications were also brought out:

(i) SOME ASPECTS OF FOOD RESEARCH: pp. 62+vi, Royal 8vo. Revised and enlarged edition containing information on processes and products developed at the Institute to give a general idea to the scientists, industry and well informed public about the work carried out, patents taken out by the Institute, processes released to Industry and ready for exploitation.

(ii) CASHEW AND SPICES: pp. 16, Dy. 8vo. The revised edition covers the new lines of work carried out at the Institute on cashew, pepper, garlic, asafoetida, ginger, mustard and chillies, and also gives statistics of their production.

(iii) LIST OF PUBLICATIONS: pp. 148, Dy. 8vo. The booklet gives information on more than 1,000 research papers published by the Institute since its inception; classified subject-wise with author index.

(iv) BROCHURE ON EQUIPMENT: pp. 16, Royal 8 vo. (oblong)—a write-up with colour illustrations on equipment or instruments designed and developed at the Institute; specially brought out for the Indian Industries Fair, New Delhi.

(v) MANGO—MONOGRAPH FOR THE INDUSTRY: pp. 60+vi, Dy. 8vo. The monograph gives comprehensive information to the industry on fuller utilization of mango. Some new types of mango products which offer scope for large-scale production and utilization are mentioned. It gives cost estimates, dealers in equipment and machinery, importers etc., connected with the industry.

(vi) ANNUAL REPORT FOR 1960-61—pp. 112 + viii, Dy. 8vo.

(vii) INDIAN MPF RECIPES—pp. 16, Cr. 8vo. (oblong).

(viii) ILLUSTRATED FOLDERS:

(a) On the activities of the Institute (pp. 8, Dy. 8vo.) both in English and in Hindi; brought out, specially for distribution at Indian Industries Fair, New Delhi.

(b) On vegetable curd (pp. 6, Dy. 8vo.), with illustrations and in colour in English, Kannada and Urdu; POSTERS in Hindi, Kannada and English.

(ix) RECIPES ON GROUNDNUT CURD in English and Kannada.

(x) KHADYA ANUSANDHAN KE KUCH PAHALU (Hindi): pp. 24, Cr. 4to—contains information on the processes and products developed at the Institute for Hindi knowing public.

13.6.4 Other publications in press: (i) SYMPOSIUM ON FOOD NEEDS AND RESOURCES, National Institute of Sciences of India. Twenty six papers comprise this publication; (ii) Revised edition of HOME-SCALE PREPARATION OF FRUITS AND VEGETABLES (contains information on the canning, bottling, drying of fruit and vegetables, preparations of juices, squashes, jams, jellies etc., with the distribution and regional names of fruits and vegetables).

13.7 Library service

The activities of the library comprise work under the following main heads: (i) acquisition of publications; (ii) service to the readers and (iii) library statistics.

13.7.1 Acquisition of publications: (a) The number of publications added during the year was 444. These have been classified and catalogued. The number of catalogue cards and acquisition cards prepared is more than 1,332.

(b) 391 sets of periodicals were received in the library. Of these, 184 were subscribed and the rest received on exchange or *gratis*. Current issues of periodicals numbering 4,176 were received and registered and 951 volumes were got bound.

13.7.2 Service to the readers: The weekly acquisitions of books have been announced in the weekly notice of the Institute.

The lists of latest issues of journals covering a total receipt of 4,176 issues, have been prepared from time to time and placed on the reading room table.

There has been considerable increase in loan service. Total number of loan transactions during the year was 12,360; inter-library loan being 20. In addition, about 47,100 consultations were made by the readers.

Students of the University as well as of Medical College, Mysore and technical staff of the Defence Food Research Laboratory, Mysore have been permitted to use the library for reference work.

13.7.3 Library statistics: A monthly library bulletin has been started from March 1962. It contains the list of the recently arrived books, standards, bulletins and pamphlets as well as abstracts of reports and reprints.

13.8 Translation and foreign language teaching

13.8.1 Translation: Fifteen research and technical articles appearing in different language journals were translated into English.

13.8.2 Teaching: New classes in French and German were begun in March 1962; the number attending each class and progress made are shown below:

	No. of students	Progress
1. Elementary German	15	Half course is over.
2. Advanced German	2	Course is three-fourths over.
3. Elementary French	5	One-fourth course is over.
4. Advanced French	3	One-fourth course is over.

13.9 Technical seminars

Twenty eight technical seminars by the staff of the Institute were arranged. In addition, 12 special seminars by distinguished scientists from outside the Institute were arranged.

13.10 Indian languages teaching

13.10.1 Hindi teaching: Hindi classes for the Prabodh, Praveen and Pragya standards were held regularly as usual for the benefit of officer pupils of the Institute.

Name of course	No. of candidates
Prabodh	21
Praveen	24
Pragya	4

13.10.2 Kannada teaching: In accordance with the recent instructions of the Government of India in respect of the essentiality of acquiring knowledge of the regional language, arrangements are being contemplated for organizing teaching classes in Kannada for the benefit of those members of the Institute who do not know any of the southern languages.

13.11 Photo-art service

The following table gives the volume of photographic and art work done:

Photographs taken	
(including 35 mm., 2 B size and 9 × 12 cm.)	... 885
Photomicrographs	... 150
Colour photograph	... 82
Bromide prints	
(including all sizes from 2 B to 10" × 12")	... 940
Graphs	... 325
Nutritional charts (20" × 30")	... 20
Labels and name-plates etc.	... 80

13.12 Exhibition service

The Institute participated in the following exhibitions:

1. The Indian Industries Fair 1961 at New Delhi (Nov. 14, 1961 to Jan. 10, 1962).

2. Field Day Celebrations Exhibition, Coffee Research Station, Balehonnur, (December 16-17, 1961).
3. National Agricultural Fair at Madras (Jan. 15—Feb. 28, 1962) in collaboration with the Ministry of Food, Government of India.

13.13 Other activities

13.13.1 Visitors service: As in previous years and as a regular activity of the Division, the visitors in general were taken round in two batches daily and the research work carried out at the Institute was explained to them. More than 10,000 general visitors were taken round during the year.

In addition, special arrangements were made for delegates to conference, distinguished visitors from educational institutions, whose visits were arranged by prior appointment.

13.13.2 News clippings service: The activity, which had for some unavoidable reason, been overlooked for sometime during the past, was revived in right earnest in the beginning of 1962 and clippings numbering 40-60 on subjects relating to Food Science and Technology have been collected every month. A more concentrated attention is being given with a view to improving its utility.

13.13.3 Reprints mailing service: Requests are received from research workers and educational and research institutions for supply of reprints on various papers published from this Institute and every effort is made to provide all available information to the interested parties. During the year under report, 450 requests from different parties in India and 1,000 parties from overseas countries were received and the required reprints supplied. The number of reprints for each request ranged from individual to individual and, in many cases, was in excess of 40-50 different papers.

13.13.4 Projection and recording services: One of the important services rendered by this Division relates to the projection of films and slides, setting up public address system for gatherings and recording of speeches and programmes. During the year under report, 24 films each of 1½-2 hours duration, mike and slide projection for 52 meetings each of 2-2½ hours duration, and recording of 6 speeches and public programmes covering a tape length of 6,000 feet, were attended to.

13.13.5 Sale of publications and M.P.F.: A number of priced publications are supplied against specific orders. During the year under report, the receipts accruing from these sales amounted to Rs 4,500. More than 1,000 transactions are estimated to have been involved therein.

Supply arrangements of multi-purpose food valued at Rs 50,000 were made with a view to enhancing its popularity and wide-scale use by different people in the length and breadth of the country and in some cases in neighbouring countries also.

APPENDIX I

PUBLICATIONS AND RESEARCH PAPERS

Periodicals

Food Science	<i>Monthly</i>
Khadya Vigyan (Hindi)	<i>Quarterly</i>
Ahara Vijnana (Kannada)	<i>Quarterly</i>

Books and monographs

Symposium on Proteins, pp. 454, Cr. 4to (published by the Central Food Technological Research Institute, Mysore for Chemical Research Committee of the Council of Scientific and Industrial Research and Society of Biological Chemists, India), 1961.

Research papers

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2. Aiyar, A. S. and Sreenivasan, A., Metabolism of vitamin B₁₂ in the rat in pantothenic acid deficiency, *Indian J. med. Res.*, 1962, **50**, 89.
3. Aiyar, A. S. and Sreenivasan, A., Metabolic inter-relationships between vitamin B₁₂ and pantothenic acid in the rat, *J. Nutr.*, 1961, **75**, 235.
4. Aiyar, A. S. and Sreenivasan, A., Intracellular distribution and biosynthesis of ubiquinone in rat liver in carbon tetrachloride liver injury, *Biochem. J.*, 1962, **82**, 179.
5. Aiyar, A. S. and Sreenivasan, A., Studies on biosynthesis of coenzyme A *in vitro* by rat tissues, *Indian J. med. Res.*, 1962, **50**, 95.
6. Aiyar, A. S. and Sreenivasan, A., Inter-relationships between vitamin B₁₂ and pantothenic acid in the rat in experimental thyrotoxicosis, *Indian J. med. Res.*, 1962, **50**, 262.
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8. Amin, H. D. and Bhatia, B. S., Studies on dehydration of some tropical fruits—Part V: Nutritive value of products, *Food Sci.*, 1962, **11**, 85.
9. Anandaswamy, B. and Iyengar, N. V. R., Pre-packaging studies on fresh snap beans (*Phaseolus vulgaris*), *Food Sci.*, 1961, **10**, 279.
10. Anantharaman, K., Subramanian, N., Bhatia, D. S., Swaminathan, M., Sreenivasan, A. and Subrahmanyam, V., Nutritional studies on screwpress groundnut cake and groundnut protein isolate, *Food Sci.*, 1961, **11**, 1.
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12. Bhatia, B. S., Amin, H. D. and Girdhari Lal, Studies on dehydration of some tropical fruits—Part I: Absorption and retention of sulphur dioxide during sulphuring and sulphiting, *Food Sci.*, 1962, **11**, 63.

13. Bhatia, B. S. and Amin, H. D., Studies on dehydration of some tropical fruits—Part III: Packaging and storage aspects, *Food Sci.*, 1962, **11**, 76.
14. Bhatia, B. S., Amin, H. D. and Girdhari Lal, Studies on dehydration of some tropical fruits—Part IV: Organoleptic quality of products, *Food Sci.*, 1962, **11**, 82.
15. Bhuvaneshwaran, C., Rege, D. V. and Sreenivasan, A., Influence of utilizable nitrogenous constituents on induced catalase synthesis in yeast, *Enzymologia*, 1961, **23** (F.A.S.C. 4), 194.
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APPENDIX II

PATENTS

Sl. No.	Patents	Patent No.	Date on which sealed, accepted or filed
1.	A new flavouring substance from waste black pepper and common salt—T. Nanjappa R. Rao, C. T. Dwarakanath and D. S. Johar	67931	Sealed on 4-11-1961
2.	Improvements in or relating to spin pasteurizers for canned acid foods—J. S. Pruthi, P. K. Ramanathan and Girdhari Lal	69697	Sealed on 14-11-1961
3.	Manufacture of vegetable milk powder—N. L. Lahiry, L. V. L. Sastry, S. R. Shurpalekar, M. R. Chandrasekhara, M. Swaminathan and V. Subrahmanyam	70049	Sealed on 27-3-1962
4.	An air separator—Y. K. Raghunatha Rao	70555	Accepted on 30-10-1961
5.	A new surgical suturing instrument—A. P. Jayaraj	77449	Filed on 3-7-1961
6.	A process for the preparation of calcium based water soluble or dispersible proteins—M. Srinivasan	79596	Filed on 1-12-1961
7.	Improvements relating to the process for insect-proofing of gunny bags for storage of foodgrains—S. K. Majumder, J. K. Krishna Rao and H. G. Sethumadhavan	81279	Filed on 17-3-1962

APPENDIX III

MEMBERSHIP OF COMMITTEES AND OTHER DISTINCTIONS CONFERRED ON STAFF

DR V. SUBRAHMANYAN

Distinctions

Nominated as the recipient of the **Babcock-Hart Award** of the Institute of Food Technologists, U.S.A., for the year 1962 for contributions to food technology which have resulted in improved public health through some aspect of nutrition or more nutritious food. The Award was received in person at the Annual Meeting of the Institute of Food Technologists at Miami on 11th June 1962.

Nominated by the University of Baroda for **K. G. Naik Gold Medal Award** to be received at the Convocation scheduled to be held on 18th September, 1962 for outstanding contributions in Chemistry and Applied Chemistry during the past quinquennium.

Deputations overseas

Meeting of the WHO/FAO/UNICEF Protein Advisory Group (PAG) held at Rome during March 1962.

World tour during May—August 1962, covering visits to:

FAO and WHO headquarters in Rome and Geneva;
Tropical Products Institute, London;
Southern Regional Research Laboratory, New Orleans;
National Institute of Health, Bethesda;
Massachusetts Institute of Technology, Boston;
Institute of Food Technologists, Ottawa;
Canadian Freedom from Hunger Campaign, Ottawa;
Meals for Millions Foundation, Los Angeles;
Japanese Nutritionists and Food Technologists Institute at Tokyo;
Dr Pascual and his group at Manila;
Australian Food Technologists at Sydney and Melbourne;
Food Technologists at Auckland, Wellington and Christ Church (New Zealand) etc.
and several discussions, press interviews, radio talks and television broadcasts at different centres in the United States, Canada, Australia and New Zealand.

Membership of Committees

Protein Advisory Group of the United Nations bodies.
National Nutrition Advisory Committee, Ministry of Health.
Expert Committee on colourisation of *vanaspati*, Ministry of Food and Agriculture.
Development Council for Sugar Industry, Ministry of Food and Agriculture.
Milk Products Committee, Ministry of Commerce and Industry.
Castor Oil Sub-Committee, Ministry of Commerce and Industry.
Technical Development Committee, Ministry of Industry and Commerce.
Inter-Ministerial Agricultural Production Board of I.C.A.R.
Horticulture Development Board of the I.C.A.R.
Soil Science Committee (Reconstituted) of the I.C.A.R.
Chairman, Technological Research Sub-Committee of the Indian Central Arecanut Committee.

Chairman, Technological Research Sub-Committee of the Indian Central Coconut Committee.

Animal Nutrition Committee of the I.C.A.R.

Dairy Science Committee of the I.C.A.R.

Chairman, Soft Drinks Sectional Committee, AFDC: 25 of the I.S.I.

Ad-hoc Sub-Committee, Containers for Pesticides, I.S.I.

Working Group on Production and Utilization, Directorate General of Health Services.

Ad-hoc Team of Dairy Experts to undertake the Achievement and Audit of National Dairy Research Institute, Karnal and its Southern Regional Station, Bangalore, Ministry of Food and Agriculture.

Sardar Vallabhbhai Vidyapeeth—Board of Visitors.

Chairman, one of the sessions of the First International Congress of Food Science and Technology to be held in London during September 1962.

President, Association of Food Technologists (India).

DR A. SREENIVASAN

Deputation Overseas

Meeting of the WHO/FAO/UNICEF Protein Advisory Group (PAG) at New York during June 1961.

Participant as an invitee to symposium on 'Unsolved Problems of Thiamine' organised by the New York Academy of Sciences at New York, during September 1961.

Participant in the Conference organised by the 'International Federation for Investigation of the Quality of Edible Plants' held at Weisbaden, West Germany during April 1962.

Membership of Committees

WHO Expert Advisory Panel on Nutrition.

Cardio-vascular Diseases and Hypertension Sub-Committee of I.C.M.R.

Working Group on 'Dietary Factors in Cholesterologenesi and Atherosclerosis' of the I.C.M.R.

Sub-Committee on 'Survey and Utilization of Agricultural and Industrial Wastes', of the Planning Commission, Government of India.

Sectional Committee for Biochemistry of the National Institute of Sciences of India.

Sub-Committee 'to formulate a Scheme on National Basis to Prevent Dietary Diseases such as Lathyrism and Fluorosis' of the National Nutrition Advisory Committee, Govt. of India.

Sub-Committee 'to review the nutritional requirements of a working class family' of the National Nutrition Advisory Committee of the Government of India.

Biological and Medical Advisory Committee of the Department of Atomic Energy.

Advisory Committee on 'Application of Atomic Energy to Food and Agriculture' of the Department of Atomic Energy.

Steering Committee for organization of a symposium on 'Vitamin Metabolism,' National Institute of Sciences of India.

Vice-President (Foreign) of the First International Congress of Food Science and Technology to be held in London during September 1962.

Lecturer (by invitation), Advance Study Course organised by the Low Temperature Research Station, University of Cambridge, Agricultural Research Council, Cambridge and the Department of Food Science, Royal College of Science and Technology, Glasgow during September, 1962.

DR D. S. BHATIA

Deputation Overseas

Participant in the First International Congress of Food Science and Technology to be held in London during September, 1962.

Lecturer (by invitation), Advance Study Course organised by the Low Temperature Research Station, University of Cambridge, Agricultural Research Council, Cambridge and the Department of Food Science, Royal College of Science and Technology, Glasgow during September, 1962.

Membership of Committees

Fisheries Technological Station Committee for Expansion and Development of the activities of Fisheries Technological Station, Cochin.

Convener, Chicory Sub-Committee, AFDC 10:8 of I.S.I.

Convener, Cereal Products Sub-Committee, AFDC 10:3 of I.S.I.

Reconstituted Edible Starches, Confectionery and Cereal Products Sectional Committee, AFDC 10 of I.S.I.

Dairy Science Committee of the I.C.A.R.

Research Committee, Food Development Council of the Ministry of Commerce and Industry.

DR M. SRINIVASAN

Membership of Committees

Sub-Committee to review the data collected by the Directorate of Marketing and Inspection on *Ghee*—Directorate-General of Health Services.

Sub-Committee of the C.C.F.S. to examine the existing standards in the light of the complaints received from the public as well as to review the existing standards at regular intervals.

Alternate Member of Edible Starches-Confectionery and Cereal Products Sectional Committee (Reconstituted), AFDC 10 of I.S.I.

DR M. SWAMINATHAN

Deputation Overseas

Participant in FAO/WHO Committee meeting on 'Calcium Requirements' held in Rome during May 1961.

Membership of Committees

School Health Committee, Ministry of Health.

Methods of Test for Dairy Products Sub-Committee, AFDC 12:4 of I.S.I.

DR N. L. LAHIRY

Membership of Committees

Meat and Meat Products Sectional Committee, AFDC 18 of I.S.I.

Piggery Products Sub-Committee, AFDC 18:2 of I.S.I.

Meat and Meat Products Sub-Committee, AFDC 18:3 of I.S.I.

Poultry Committee of the Indian Council of Agricultural Research, New Delhi.

Fish and Fish Products Sub-Committee, AFDC 18:4/T of I.S.I.

Milk, Meat and Fish Products Panel, Development Council for Food Processing Industries, Ministry of Commerce and Industry, Government of India.

Sub-committee to examine measures for development of Meat Technology, Ministry of Food and Agriculture, Department of Food, Government of India.

DR G. S. SIDDAPPA

Distinctions

Fellow of the Royal Institute of Chemistry, London, in May 1962.

Recipient of 'Kashalkar Memorial Award' by the All India Food Preservers' Association for technical assistance to industry.

Membership of Committees

Processed Fruit and Vegetable Sub-committee, AFDC 23:3 of I.S.I. Horticultural Development Board, I.C.A.R.

Central Fruit Products Advisory Committee, Government of India. Convener, Technical Advisory Committee for 1962, All India Food Preservers' Association.

SHRI A. RAHMAN

Deputation Overseas

Tenth International Congress of History of Sciences, Cornell University, Ithaca, to be held during August 1962.

To discuss problems of scientific information and documentation, storage and retrieval of information and library services at National Science Foundation; Library of Congress; National Library of Medicine; National Agricultural Library; National Bureau of Standards; Office of the Technical Services; Department of Commerce at Washington; Department of Scientific and Industrial Research (U.K.) and Tropical Products Institute, London, during September 1962.

Fifth International Food Congress and Exhibition at New York, during September 1962.

To study Operational Research in Food Industries in U.K., during September 1962.

Participation in First International Congress on Food Science and Technology to be held in London, during September 1962.

To attend the Advance Study Course in Biochemistry and Biophysics organized by the University of Cambridge and Agricultural Research Council, Cambridge, during September 1962.

Membership of Committees

1. Secretary, Operational Research Society of India.
2. Social Relations of Science Committee of the Indian Science Congress Association.
3. Board of History of Science of the National Institute of Sciences of India.
4. In-charge, Medieval India Unit of the National Institute of Sciences of India, History of Science Project.
5. Editorial Board, Operational Research Society News-letter.

SHRI H. C. BHATNAGAR

Membership of Committee

Sub-committee of the Horticulture Development Board of the I.C.A.R. to consider Freight and Transport of Fruits and Vegetables.

DR H. C. SRIVASTAVA

Distinctions

Fellow of Royal Horticultural Society, London.
Member, New York Academy of Sciences, U.S.A.

Membership of Committees

Sub-committee of Horticultural Development Board of the I.C.A.R. on Freight and Transport of Fruits and Vegetables.
Research Committee on Packaging and Transportation Problems of Railway Board.
Committee of I.C.A.R. to draw up a co-ordinated scheme for investigations in cold storage and storage diseases of fruits and vegetables.
Project Co-ordinator of co-ordinated scheme on researches on refrigerated storage behaviour of fruits and vegetables at 8 centres under the auspices of the I.C.A.R.

SHRI S. K. MAJUMDER

Membership of Committees

Pest Control Products Sectional Committee, AFDC 6; I.S.I.
Storage Advisory Committee, Department of Food, Ministry of Food and Agriculture, Government of India.
Storage and Marketing Structures Co-ordinating Committee, AFDC 1, I.S.I.

DR J. S. PRUTHI

Membership of Committees

Sectional Committee on Spices and Condiments, AFDC 21 of I.S.I.
Sub-committee on Spices and Condiments for Draft specifications, AFDC 21:1 of I.S.I.
Panel for Chemical Analysis of Spices, AFDC 21/P1 of I.S.I.
(Alternate Member), Sectional Committee on Fruits and Vegetables, AFDC 23 of I.S.I.
(Alternate Member), Sub-committee for Processed Fruits and Vegetables, AFDC 23:3 of I.S.I.
Secretary, Technical Development Committee for Spices (TDCS), Spices Export Promotion Council, Government of India.
Indian Central Spices and Cashewnut Committee, Ministry of Food and Agriculture, Government of India.
Secretary, Technological Sub-committee of Indian Central Spices and Cashewnut Committee, Government of India.

DR S. S. KALBAG

Deputation Overseas

To West Germany, Denmark and U.K. for selecting suitable spray-drying and centrifuge equipment after study of their performance for use in the plant for the integrated processing of groundnuts, which is being set up at Bombay.

SHRI V. S. GOVINDARAJAN

Membership of Committee

Arecanuts Sub-committee, AFDC 23:5 of I.S.I.

(MAJOR) N. V. R. IYENGAR

Membership of Committees

Research Committee on Packaging and Transportation Problems, Railway Board.

Polyethylene Film and Laminates Sub-committee, CDC 17:8 of I.S.I.
Soft Drinks Carbonated Water Committee, AFDC 25:1 of I.S.I.
Plastics Committee of I.S.I.
Packaging, Storage and Transport of Fruits and Vegetables Committee,
I.S.I.
Pilfer Proof Packaging Sub-committee of the C.C.F.S., Ministry of Health.

DR H. S. R. DESIKACHAR

Membership of Committee

Cereals and Pulses Sectional Committee, AFDC 26 of I.S.I.

DR R. RAJAGOPALAN

Membership of Committee

Utensils Sectional Committee, AFDC 47 of I.S.I.

DR T. N. RAMACHANDRA RAO

Membership of Committees

Indian Council of Medical Research working party to carry out a survey
and prepare a report in regard to the waste disposal problem in food and
fermentation industries in the country.

(Alternate), Spices and Condiments Sub-committee, AFDC 21 of I.S.I.

DR D. P. SEN

Deputation overseas

For advanced training in fish technology at the Torry Research Station,
Aberdeen, England, under Colombo Plan.

Sponsored Schemes under supervision of

DR A. SREENIVASAN

1. Nutritional aspects of cell metabolism—Indian Council of Medical Research.
2. Experimental studies on certain vegetable protein foods in the treatment and prevention of protein malnutrition—Williams Waterman Fund Research Corporation.
3. Metabolic inter-relationships between folic acid and vitamin B₁₂—Department of Atomic Energy, Government of India.

DR D. S. BHATTIA

1. Research on coffee technology—Coffee Board.
2. Research on tea technology—Tea Board.

DR M. SRINIVASAN

Nutritive value of foodstuffs—Indian Council of Medical Research.

A. RAHMAN

History of sciences in medieval India—National Institute of Sciences of India.

DR G. S. SIDDAPPA

Analysis of trade samples under Fruit Products Order—Ministry of Agriculture, Government of India.

APPENDIX IV

LIST OF JOURNALS

A: *Ad hoc*. **B:** Bi-monthly. **E:** Exchange.
F: Fortnightly. **G:** Gratis Half yearly **M:** Monthly.
Q: Quarterly. **S:** Subscription. **Y:** Yearly.
W: Weekly.

	Vol. No.	Year	Perio- dicity
Abstracts from Current Medical Literature		(1961-)	Q
Advancement of Science (S)	1	(1939-)	B
Aahara Vignana (G) (<i>Kannada</i>)	1	(1956-)	Q
Agricultural and Biological Chemistry (S)	25	(1961-)	M
Agricultural Marketing (S)	5	(1962-)	Q
Agricultural Research (S)	1	(1961-)	Q
Agricultural Situation in India (S)	7	(1952-)	M
A.I.Ch.E. Journal (S)	3	(1957-)	Q
A.I.G.M.F. Bulletin (E)	4	(1958-)	Q
ALMANAC of the Canning, Freezing, Preserving Industries (S)		(1951-)	Y
American Documentation (S)	3	(1962-)	Q
American Journal of Clinical Nutrition (S)	3	(1955-)	M
American Journal of Public Health (S)		(1962-)	M
American Miller and Processor (E)	85	(1957-)	M
Andhra Agricultural Journal (E)	1	(1954-)	B
Analyst (E)	51	(1939-)	M
Analytica Chimica Acta (S)	1	(1947-)	M
Analytical Abstracts (E)	1	(1954-)	M
Analytical Biochemistry (S)	1	(1960-)	M
Analytical Chemistry (S)	25	(1953-)	M
Angewandte Chemie (S)	64	(1952-)	M
Anales de Bromatologia (E) (<i>Spanish</i>)	10	(1958-)	Q
Annals of Library Science (S)	9	(1962-)	Q
Annals of the New York Academy of Sciences (S)	89	(1960-)	A
Annual Review of Food Technology (G)	1	(1959-)	Y
Annals of Applied Biology (S)	36	(1949-)	Q
Annals of Biochemistry and Experimental Medicine (E)	1	(1941-)	M
Annual Report on the Progress of Chemistry (S)	51	(1954-)	Y
Annual Report on the Progress of Applied Chemistry (S)	39	(1954-)	Y
Annual Review of Biochemistry (S)	1	(1932-)	Y
Annual Review of Entomology (S)	1	(1956-)	Y
Annual Review of Medicine (S)	1	(1950-)	Y
Annual Review of Microbiology (S)	1	(1947-)	Y
Annual Review of Physiology (S)	1	(1939-)	Y
Annual Review of Plant Physiology (S)	1	(1950-)	Y
Antiseptic (E)	52	(1955-)	M
Applied Microbiology (S)	1	(1953-)	B
Archives of Biochemistry and Biophysics (S)	10	(1943-)	M
Arecanut Journal (G)	5	(1954-)	Q
ASHRAE Journal (S)	1	(1959-)	M
Association of Food and Drug Officials of the U.S. Bulletin (E)	17	(1953-)	Q
Audio-Visual Education (S)	5	(1961-)	Q
Australian Journal of Agricultural Research (E)	1	(1950-)	Q

	Vol. No.	Year	Perio- dicity
Australian Journal of Applied Science (E)	1	(1950-	) Q
Australian Journal of Biological Science (E)	14	(1961-	) Q
Australian Food Manufacture and Distributor (E)	16	(1947-	) M
Australian Journal of Dairy Technology (E)	13	(1958-	) Q
Australian Journal of Marine and Fresh-Water Research (E)	1	(1950-	) Q
Australian Journal of Science (E)	12	(1949-	) Q
Bacteriological Reviews (G)	17	(1953-	) Q
Baker and Confectioner (E)	117	(1950-	) M
Baking Abstracts (E)	54	(1954-	) B
Bibliography of Agriculture (E)	16	(1952-	) M
Bibliography of Literature on Plant Protection (E)		(1949-	) A
Bibliography of Scientific Publications of South and S.E. Asia (S)		(1949-	) M
Biochemical Journal (S)	27	(1933-	) M
Biochemical and Biophysical Research Communications (S)	1	(1959-	) W
Biochemische Zeitschrift (S) (<i>German</i>)	323	(1952-	) M
Biochemistry (S)	1	(1962-	) B
Biochemistry (USSR). (S)	26	(1961-	) B
Biochimica et Biophysica Acta (S)	1	(1947-	) W
Biological Abstracts (S)	27	(1953-	) F
Biometrics (S)	4	(1948-	) Q
Biomitrika (S)	39	(1952-	) H
Biotechnology and Bioengineering (S)	1	(1959-	) Q
Bolten de la oficina Sanitaria Panamericana (G)	45	(1958-	) M
Bordens Review of Nutrition Research (E)	11	(1950-	) Q
Bottler and Packer (S)	22	(1948-	) M
British Food Manufacturing Industries Research Association Abstracts (E)	8	(1955-	) M
British Food Journal and Hygienic Review (S)	38	(1936-	) M
British Journal of Nutrition (S)	3	(1949-	) Q
British Chemical Engineering (S)	2	(1957-	) M
British Medical Bulletin (S)	6	(1949-	) Q
British Patents (Group VI) (E)		(1957-	) A
British Medical Journal (S)		(1952-	) W
British Packer (E)	17	(1955-	) M
British Sugar Beet Review (G)	24	(1956-	) Q
Brot and Geback (E) (<i>German</i>)	10	(1956-	) M
Bulletin Signaletique (S) (<i>French</i>)	13	(1952-	) M
Bulletin de la Societa de Chimie Biologique (E) (<i>French</i>)	33	(1951-	) M
Bulletin of the Central Leather Research Institute (E)	1	(1954-	) M
Bulletin of Entomological Research (S)	43	(1952-	) B
Bulletin of the International Institute of Refrigeration (E)	29	(1949-	) B
Canadian Entomologist (S)	89	(1957-	) M
Canadian Food Industries (S)	19	(1948-	) M
Canadian Journal of Animal Science (G)	37	(1957-	) H
Canadian Journal of Botany (S)	29	(1951-	) B
Canadian Journal of Chemistry (E)	29	(1951-	) M
Canadian Journal of Biochemistry and Physiology (S)	32	(1954-	) M
Canadian Journal of Microbiology (E)	1	(1954-	) B
Candy Industry and Confectioners Journal (E)	111	(1958-	) M

	Vol. No.	Year	Perio- dicity
Canadian Journal of Zoology (S)	29	(1951-)	B
Canadian Journal of Plant Science (G)	37	(1957-)	H
Canadian Journal of Soil Science (G)	37	(1957-)	H
Canner/Packer (S)	128	(1959-)	M
Canning and Packing (S)	24	(1954-)	M
Canning Trade (S)	70	(1948-)	W
California Citrograph (S)	28	(1942-)	M
Cement and Concrete (G)	1	(1961-)	Q
Central Glass and Ceramic Research Institute Bulletin (E)	2	(1955-)	Q
Ceylon Coconut Quarterly (E)	3	(1952-)	Q
Central Public Health Engineering Research Institute Bulletin (G)	1	(1959-)	Q
Cereal Chemistry (S)	1	(1924-)	B
Cereal Science Today (E)	2	(1957-)	M
Chemical Abstracts (S)	14	(1920-)	F
Chemical Age (S)	60	(1949-)	W
Chemical Engineering (S)	60	(1953-)	F
Chemical and Engineering News (S)	31	(1953-)	W
Chemical Engineering Progress (S)	48	(1952-)	M
Chemical Engineering Science (S)	7	(1957-)	M
Chemical Processing (G)	4	(1958-)	M
Chemical and Process Engineering (S)	33	(1952-)	M
Chemical Products (S)	12	(1949-)	M
Chemical Reviews (S)	39	(1946-)	B
Chemical Trade Journal (S)	125	(1949-)	W
Chemical Week (S)	17	(1952-)	W
Chemie-Ingenieur-Technic (S) (<i>German</i>)	24	(1952-)	M
Chemist Analyst (G)	44	(1955-)	Q
Chemistry and Industry (S)		(1947-)	W
Chemurgic Digest (E)	7	(1949-)	M
Chinese Medical Journal (E)	81	(1962-)	M
Chronicle of the W.H.O. (E)	5	(1951-)	M
Clinica Chimica Acta (S)	1	(1956-)	M
Coconut Bulletin (G)	8	(1954-)	M
Coffee and Tea Industries and the Flavour Field (E)	75	(1952-)	M
Commercial Fisheries Abstracts (E)	11	(1958-)	M
Commercial Fisheries Review (E)	14	(1952-)	M
Comparative Biochemistry and Physiology (S)	5	(1962-)	M
Confectionery and Baking Craft (E)	45	(1951-)	M
Confectionery Production (E)	18	(1952-)	M
Control Engineering (S)	5	(1958-)	M
Current Science (S)	9	(1940-)	M
Dairy Science Abstracts (E)	10	(1948-)	M
Defence Science Journal (G)	7	(1957-)	Q
Deutsche Lebensmittel-Rundschau (E) (<i>German</i>)	48	(1952-)	M
Die Industrielle Obst-Und Gemuseverwertung (E) (<i>German</i>)	38	(1953-)	M
Diabetes (S)	10	(1961-)	B
Die Neue Verpackung (E) (<i>German</i>)	5-11	(1952-58)	M
Die Nahrung (G) (<i>German</i>)	4	(1960-)	M
Dietologia (E)	9-10	(1951-52)	Q
Discovery (S)	6	(1945-)	M

	Vol. No.	Year	Periodicity
Economic Botany (S)	9	(1955-)	B
Empire Journal of Experimental Agriculture (S)	21	(1953-)	Q
Endeavour (G)	1	(1942-)	Q
Enzymologia (S)	1	(1936-)	M
Ernährungsforschung (G) (<i>German</i>)	5	(1960-)	B
Experimental Cell Research (S)	1	(1942-)	M
Extension (S)	2	(1962-)	M
Federation Proceedings (S)	1	(1942-)	Q
Far East Trade (G)	16	(1961-)	M
Fette Seifen Anstrichmittel (E) (<i>German</i>)	57	(1955-)	M
Fish Technology Newsletter (G)	1	(1960-)	Q
Fisheries Newsletter (E)	16	(1957-)	M
Fishing Gazette (E)	69	(1952-)	M
Food Processing and Packaging (E)	10	(1941-)	M
Food Directory (S)		(1954-)	A
Food and Cookery (E)	19	(1951-)	M
Food and Farming (E)	4	(1952-)	M
Food in Canada (E)	11	(1951-)	M
Food Engineering (S)	25	(1953-)	M
Food Industries of South Africa (E)	6	(1953-)	M
Food Irradiation Quarterly (G)	1	(1960-)	Q
Food Manufacture (S)	14	(1939-)	M
Food Marketing (G)	1	(1961-)	Q
Food Preservation Quarterly (E)	4	(1941-)	Q
Food Research Institute Studies (S)	3	(1962-)	Q
Food Science (G)	1	(1950-)	M
Food Technology (S)	1	(1941-)	M
Food Technology in Australia (E)	4	(1952-)	M
Food Trade Review (S)	18	(1948-)	M
French Science News (G)		(1959-)	Q
Foreign Agriculture (E)	16	(1952-)	M
Fruits (E) (<i>French</i>)	8	(1953-)	M
Glass Packer (E)	27	(1948-)	M
Glaxo Volume (G)	11	(1956-)	A
Hamdard Medical Digest (G)	6	(1962-)	B
Harvey Lectures (S)	1	(1950-)	A
Heat Treatment Journal (G)	8	(1961-)	Q
Health and Welfare (E)	7	(1960-)	M
Hercules Chemist (G)	32	(1958-)	A
Hindustan Antibiotics Bulletin (E)	1	(1958-)	Q
Himachal Horticulture (E)	1	(1960-)	Q
Horticultural Abstracts (S)	18	(1948-)	Q
Horticultural Advance (S)	11	(1957-)	A
Husipar (G) (<i>Hungarian</i>)	9	(1960-)	B
Imda Journal (G)	3	(1959-)	M
Impact of Science (S)	11	(1961-)	Q
Indian Bee Journal (E)	14	(1953-)	B
IASLIC Bulletin (S)	7	(1962-)	Q
Indian Agriculturist (E)	3	(1959-)	H

	Vol. No.	Year	Perio- dicity
Indian Coffee (E)	17	(1953-	) M
Indian Concrete Journal (S)	28	(1954-	) M
Indian Dairyman (S)	1	(1949-	) M
Indian Farming (S)	5	(1955-	) M
Indian Food Packer (E)	1	(1947-	) M
Indian Horticulture (S)	1	(1956-	) Q
Indian and Eastern Engineer (E)	112	(1953-	) M
Indian Journal of Dairy Science (S)	1	(1948-	) Q
Indian Journal of Applied Chemistry (E)	21	(1958-	) B
Indian Journal of Fisheries (E)	1	(1954-	) H
Indian Journal of Child Health (E)	8	(1959-	) Q
Indian Journal of Horticulture (S)	7	(1951-	) Q
Indian Journal of Medical Research (S)	18	(1930-	) B
Indian Journal of Medical Sciences (E)	8	(1954-	) M
Indian Journal of Pathology and Bacteriology (S)	1	(1958-	) Q
Indian Journal of Pediatrics (E)	20	(1953-	) M
Indian Journal of Plant Physiology (E)	1	(1958-	) H
Indian Journal of Physiology and Allied Sciences (S)	1	(1947-	) Q
Indian Journal of Public Health (E)	2	(1958-	) Q
Indian Journal of Sericulture (G)	1	(1962-	) M
Indian Oilseeds Journal (S)	1	(1956-	) Q
Indian Perfumer (E)	2	(1958-	) H
Indian Potato Journal (S)	1	(1959-	) H
Indian Standards Institution Bulletin (E)	1	(1949-	) B
Indian Silk (G)	1	(1962-	) M
Indian Sugar (E)	6	(1956-	) M
Ind-Com Journal (G)	10	(1955-	) Q
Industrial Chemist (S)	25	(1949-	) M
Industria Conserve (E) (<i>Italian</i>)	28	(1953-	) Q
Industrial and Engineering Chemistry (S)	1	(1909-	) M
Industries Agricoles et Alimentaires (E) (<i>French</i>)	74	(1957-	) M
International Photo Technik (S)		(1957-	) Q
Information Bulletin (Refrigeration) (G)		(1957-	) M
Institute of Meat Bulletin (G)	10	(1955-	) Q
Indian oil and Soap Journal (E)	18	(1953-	) M
Irrigation and Power (E)	10	(1953-	) Q
Insdoc List (E)	2	(1955-	) F
International Fruit World (G)	13	(1954-	) Y
International Management (S)	8	(1953-	) M
International Sugar Journal (S)	51	(1949-	) M
Jena Review (G)		(1957-	) B
Journal of Agricultural and Food Chemistry (S)	1	(1953-	) B
Journal and Proceedings of the Inst. of Chemists (<i>India</i>) (G)	26	(1954-	) B
Journal of the American Chemical Society (S)	52	(1930-	) F
Journal of the American Dietetic Association (S)	14	(1938-	) M
Journal of the American Medical Association (S)	150	(1952-	) W
Journal of the American Oil Chemists Society (E)	26	(1949-	) M
Journal of Applied Bacteriology	19	(1956-	) Q
Journal of Applied Chemistry (S)	1	(1951-	) M
Journal of Bacteriology (S)	64	(1952-	) M
Journal of Biochemistry (S)	43	(1956-	) M

	Vol. No.	Year	Periodicity
Journal of Biological Chemistry (S)	80—112	(1928—35)	M
	116	(1936))
	125—126	(1938))
	130	(1939))
	145	(1942))
	150	(1943))
	167—169	(1947))
	171—173	(1947—48))
	175—176	(1948))
	177	(1949—))
Journal of Cell Biology (S)	7	(1960—)	M
Journal of Chemical Education (S)	29	(1952—)	M
Journal of the Chemical Society (S)		(1947—)	M
Journal of the Chemistry of U.A.R. (G)	1	(1958—)	M
Journal of Chromatography (S)	1	(1958—)	M
Journal of Dairy Research (S)	17	(1950—)	Q
Journal of Dairy Science (S)	21	(1938—)	M
Journal of Economic Entomology (S)	46	(1953—)	B
Journal of the Fisheries Research Board of Canada (G)	8	(1951—)	B
Journal of Food Science (S)	1	(1936—)	B
Journal of General and Applied Microbiology (S)	8	(1962—)	Q
Journal of General Microbiology (S)	3	(1949—)	Q
Journal of Horticulture Science (S)	25	(1949—)	Q
Journal of Home Economics (S)	30	(1938—)	M
Journal of the Indian Chemical Society (E)	8	(1931—)	M
Journal of the Indian Institute of Science (E)	34	(1952—)	Q
Journal of the Indian Pediatric Society (S)	1	(1962—)	M
Journal of the Indian Society of Soil Science (G)	6	(1958—)	Q
Journal of Industry and Trade (G)	3	(1953—)	M
Journal of Insect Physiology (S)	1	(1957—)	B
Journal of Institute of Brewing (S)	49	(1943—)	B
Journal of Laboratory and Clinical Medicine (S)	24	(1939—)	M
Journal of Lipid Research (S)	1	(1959—)	Q
Journal of Milk and Food Technology (E)	13	(1950—)	M
Journal of Madras University (G)	21	(1951—)	Q
Journal of Nutrition (S)	1	(1928—)	M
Journal of Pediatrics (S)	12	(1938—)	M
Journal of Science of Food and Agriculture (S)	1	(1950—)	M
Journal of Scientific and Industrial Research (E)	4	(1945—)	M
Journal of the Society of Dairy Technology (G)	4	(1950—)	Q
Journal of A.O.A.C. (S)	21	(1938—)	Q
Journal of Tropical Pediatrics (S)	4	(1958—)	Q
Kozlemenvei (G) (<i>Czech</i>)		(1960—)	Q
Kvasny Prumyl (G) (<i>Czech</i>)		(1961—)	M
Kisani Samachar (E) (<i>Hindi</i>)		(1962—)	M
Khadya Vignan (G) (<i>Hindi</i>)	3	(1960—)	Q
Laboratory Digest (G)	14	(1950—)	M
Laboratory Animals Information Service (G)	1	(1958—)	A
Laboratory Practice (S)	11	(1962—)	M
Lancet (S)	257	(1949—)	W
Library Abstracts (G)	19	(1953—)	M
La revue de la conserve (E) (<i>French</i>)		(1954—)	M

	Vol No.	Year	Perio- dicity
Mather and Platt's Food Information Service (G)	11	(1960-	) A
Machinery Lloyd (S)	24	(1952-	) F
Machine Tool Engineer (G)	1	(1959-	) Q
Madras Agricultural Journal (E)	38	(1951-	) M
May and Baker Laboratory Bulletin (G)	4	(1960-	) A
Major Industries of India (S)	2	(1952-	) Y
Manderstam Technical Digest (E)	6	(1953-	) B
Manufacturing Confectioner (S)	32	(1952-	) M
Manufacturing Chemist (S)	33	(1962-	) M
Marketing Newsletter (G)		(1959-	) M
Medical Digest (E)	24	(1956-	) M
Metabolism (S)	6	(1957-	) M
Metal Box Co., Survey of Literature (G)		(1957-	) M
Metric Measures (S)	1	(1958-	) B
Milk Industry (E)	30	(1949-	) M
Milk Plant Monthly (E)	30	(1941-	) M
Milk Producer (E)	4	(1955-	) M
Mikrochimica Acta (S)		(1954-	) M
Milling (S)	116	(1951-	) F
Minerva Dietologica (E) (<i>Italian</i>)	1	(1961-	) Q
Modern Packaging (S)	11	(1938-	) M
Monthly Abstract of Statistics (S)	4	(1951-	) M
Monthly Statistics of the Foreign Trade of India (S)		(1957-	) M
Monthly Statistics of the Production of selected Industries of India (S)	4	(1952-	) M
Monthly Technical Review (E)	3	(1959-	) M
Museum Quarterly (S)	14	(1961-	) Q
National Register of Technical Personnel (G)		(1958-	) A
National Metallurgical Laboratory Journal (G)	1	(1959-	) Q
Nature (S)	160	(1947-	) W
Netherlands Milk and Dairy Journal (E) (<i>Dutch</i>)	4	(1950-	) Q
New Scientist (S)	13	(1962-	) W
Nickel Bulletin (G)	25	(1952-	) M
Nutrition Abstracts and Reviews (S)	1	(1931-	) Q
Nutrition (E)	5	(1951-	) Q
Nutrition Reviews (E)	3	(1945-	) M
Oils and Oilseeds Journal (E)	4	(1952-	) M
Oleagineux (G) (<i>French</i>)	16	(1961-	) M
Operational Research Quarterly (S)	12	(1961-	) Q
Operations Research (S)	9	(1961-	) Q
Packaging (E)	38	(1956-	) M
Packaging Review (E)	72	(1952-	) M
Packaging Abstracts (E)	3	(1946-	) M
Pakistan Journal of Science (E)	7	(1955-	) B
Patna Journal of Medicine (E)	32	(1958-	) M
Pakistan Journal of Scientific Research (E)	7	(1955-	) B
Peanut Journal and Nut World (S)	29	(1950-	) M
Pediatrics (S)		(1962-	) M
Perfectpec (E)	1	(1961-	) B
Perfumery and Essential Oil Record (E)	42	(1951-	) M
Pest Control (S)	30	(1962-	) M

	Vol. No.	Year	Perio- dicity
Pest Technology (S)	2	(1959-)	M
Pharmaceutist (E)	2	(1956-)	M
Physiological Reviews (S)	29	(1949-)	Q
Phytochemistry (S)	1	(1961-)	Q
Planters Chronicle (E)	49	(1954-)	F
Plant Physiology (S)	28	(1953-)	B
Poultry Science (S)	28	(1949-)	B
Proceedings of the American Society for Horticultural Science (S)	34	(1936-)	H
Prace, Instytutowi Laboratory (E) (<i>Polish</i>)	5	(1955-)	Q
Proceedings of the Chemical Society (S)		(1957-)	M
Proceedings of the Indian Academy of Sciences, (Sections A and B) (S)	10	(1939-)	M
Proceedings of the National Institute of Sciences of India, (Sections A and B)	17	(1951-)	B
Proceedings of the Nutrition Society (S)	1	(1944-)	H
Proceedings of the Nutrition Society of Southern Africa (S)	1	(1960-)	A
Prumysl Potravin (G) (<i>Czech</i>)	9	(1958-)	M
Proceedings of the Royal Society, Series B (S)	136	(1949-)	M
Productivity Journal (S)	1	(1959-)	B
Proceedings of the Society for Experimental Biology and Medicine (S)	50	(1942-)	M
Punjab Fruit Journal (E)	15	(1952-)	Q
Productivity Measurement Review (S)	24	(1961-)	Q
Qualitas Plantarum and Materiae Vegetables (S) (<i>German</i>)	1	(1954-)	Q
Quarterly Review of Biology (S)	13	(1938-)	Q
Queensland Journal of Agricultural Science (E)	8	(1951-)	Q
Quick Frozen Foods (E)	12	(1950-)	M
Refrigeration and Air conditioning Business (S)	9	(1952-)	M
Refrigeration Journal (E)	4	(1950-)	M
Research and Industry (G)	1	(1956-)	M
Review of Applied Entomology, Series A and B (S)	40	(1952-)	M
Review of Scientific Instruments (S)	20	(1952-)	M
Roczniki Wyzszej Szkoły Rolniczej W Poznaniu (G) (<i>Polish</i>)	1	(1957-)	A
Review Pratique du Froid (E) (<i>French</i>)	7	(1951-)	M
Review de la Conservel (E) (<i>French</i>)	9	(1954-)	M
Revista de agroquímica Tecnologia de Alimentos (S) (<i>Spanish</i>)	1	(1961-)	Q
Rice Journal (E)	53	(1950-)	M
Revue Technique de L' Industrie Alimentaire (G) (<i>French</i>)	57	(1957-)	A
Sanitarian (G)	65	(1956-)	Q
Sankhya (S)	12	(1952-)	Q
Samvadadhvam (G)	1	(1956-)	Q
Science (S)	86	(1937-)	Q
Scientia Sinica (E)	11	(1962-)	M
Science and Culture (S)	14	(1948-)	M
Science and Engineering (S)	11	(1958-)	B

	Vol. No.	Year	Perio- dicity
Science Progress (S)	37	(1949-)	Q
Scientific American (S)	158	(1938-)	M
Scientific Papers from Institute of Chemical Technology (G)	1	(1957-)	H
Silk Newsletter (G)	6	(1961-)	M
Seed Potato (G)	1	(1961-)	M
Silk and Rayon (G)	4	(1961-)	Q
Sharkara (E)	3	(1960a)	Q
Society of Biological Chemists, India (Annual Review)	1	(1930-)	A
Society of Biological Chemists, India (Proceedings)	1	(1936-)	A
South Indian Horticulture (E)	1	(1953-)	Q
Soyabean Digest (S)	1	(1941-)	M
SPC Quarterly Bulletin (S)	6	(1956-)	Q
Statistical Bulletin of the International Sugar Council (G)	11	(1951-)	M
Susswaren (E) (<i>German</i>)	1	(1957-)	F
Swiss Industry and Trade (E)	34	(1959-)	Q
Swiss Technics (E)		(1953-)	Q
Spices Bulletin (G)	1	(1961-)	M
Taste and Odor Control Journal (G)	28	(1962-)	M
Tea and Coffee Trade Journal (S)	100	(1951-)	M
Tea Quarterly (S)	27	(1956-)	Q
Technical Manpower (G)	2	(1960-)	M
Technology Review (S)	40	(1937-)	M
Times (Science Review) (S)		(1951-)	Q
Tin and Its Uses (G)		(1956-)	Q
Tin-Printer and Box Maker (S)	25	(1949-)	M
Thermometer (G)		(1961-)	M
Transactions of the Royal Entomological Society of London (S)	103	(1952-)	A
Tropical Agriculture (S)	29	(1952-)	Q
Tropical Agriculturist (E)	108	(1952-)	Q
Tropical Science (E)	1	(1959-)	Q
Transactions of the Institution of Chemical Engineers (S)	24	(1946-)	B
Two and A Bud (Indian Tea Assoc.) (G)	6	(1959-)	Q
Udoyg Byapar Pathrika (E)	3	(1955-)	M
Unesco Chronicle (G)	3	(1957-)	B
Unesco Bulletin for Libraries (G)	4	(1950-)	B
Vijan Karmee (G)	2	(1950-)	M
Vijnan Pragathi (G) (<i>Hindi</i>)	1	(1952-)	M
Vijnan Perishad Anusandhan Patrika (E) (<i>Hindi</i>)	1	(1958-)	Q
Voëding (E) (<i>Dutch</i>)	17	(1956-)	M
Wallerstein Laboratories Communications (E)	14	(1951-)	Q
Westermann Monatshefte (S) (<i>German</i>)	93	(1952-)	M
World Fisheries Abstracts (S)	3	(1952-)	B
World Review of Pest Control (S)	1	(1962-)	Q
Zuker—Und Suswaren Wirtschaft (E)	5	(1952-)	M
Zeitschrift fur Lebensmittel—Untersuchung Und Forschung (S) (<i>German</i>)	94	(1952-)	M

LIBRARY

Books and publications added	..	444	
Current periodicals received	..	4,176	
Number of loan transactions	..	12,360	
Inter-library loans	..	20	
Consultation service	..	47,100	
Number of publications classified	..	444	
Number of catalogue cards prepared	..	1,332	
Number of readers	..	300	
Total number of books	..	5,002	} 11,920
Total number of periodicals (bound volumes)	..	5,718	
Total number of pamphlets, bulletins etc.	..	1,200	

APPENDIX V

For 1961-62

Budget provision

(i) Recurring grant	Rs	23,53,100
(ii) Capital grant		4,08,000
(iii) Pilot plant grant		2,30,000
(iv) Receipts		5,59,203

Details of receipts

1. Rent of staff quarters	4,839
2. Rent of premises	256
3. Analytical and test charges	5,446
4. Sale proceeds of vegetables, plants etc.	576
5. Sale proceeds of journals and priced publications	8,785
6. Sale proceeds of different laboratory products	4,64,765
7. Examination and tuition fee	1,376
8. Advertisement charges	3,617
9. Other receipts	69,543
	5,59,203

Actual expenditure

(i) Recurring	23,30,500
(ii) Capital	4,08,014
(iii) Pilot plant	2,26,609

APPENDIX VI

(A) MEMBERS OF THE EXECUTIVE COUNCIL

1. Shri B. D. Jatti, Chief Minister of Mysore, Vidhana Soudha, Bangalore.
2. Dr P. S. Sarma, Prof. of Biochemistry, Indian Institute of Science, Bangalore.
3. Shri K. K. Birla, 8, India Exchange Place, Calcutta.
4. Shri N. R. Sathe, Sathe Biscuit and Chocolate Co., Ltd., 820, Bhavani Peth, P.B. No. 597, Poona 2.
5. Shri N. Srinivasan, Industrial Adviser (Chemicals), Ministry of Commerce and Industry, Udyog Bhavan, New Delhi.
6. The Director-General, Scientific and Industrial Research, Rafi Marg, New Delhi.
7. The Director, Central Food Technological Research Institute, Mysore.
8. Dr Vikram A. Sarabhai, Physical Research Laboratory, Navarangapura, Ahmedabad 9.
9. Dr D. S. Kothari, Chairman, University Grants Commission, New Delhi.
10. Dr C. Gopalan, Director, Nutrition Research Laboratory, Taranaka, Hyderabad 7.
11. Shri Chinubhai Manibhai, M/s Anil Starch Products Ltd., Anil Road, P.B. No. 93, Ahmedabad.
12. Dr S. Bhagavantham, Director, Indian Institute of Science, Bangalore 12.
13. The Financial Adviser to Council of Scientific and Industrial Research, Rafi Marg, New Delhi.
14. Shri B. B. Sardeshpande, M/s Corn Products Co., (India) Pvt. Ltd., Shree Niwas House, Waudby Road, P.B. No. 994, Bombay 1.
15. Dr P. K. Kymal, Technical Adviser, Ministry of Food and Agriculture, Government of India, New Delhi.

(B) MEMBERS OF THE SCIENTIFIC SUB-COMMITTEE

1. Dr Vikram A. Sarabhai, Physical Research Laboratory, Navarangapura, Ahmedabad 2.
2. Shri K. K. Birla, 8, India Exchange Place, Calcutta.
3. Dr C. Gopalan, Director, Nutrition Research Laboratory, Taranaka, Hyderabad 7.
4. Dr P. K. Kymal, Technical Adviser, Ministry of Food and Agriculture, Government of India, New Delhi.
5. Shri N. R. Sathe, Sathe Biscuit and Chocolate Co., Ltd., 820, Bhawani Peth, P.B. No. 597, Poona 2.
6. Shri Chinubhai Manibhai, M/s Anil Starch Products Ltd., Anil Road, Post Box No. 93, Ahmedabad.
7. Dr P. S. Sarma, Professor of Biochemistry, Indian Institute of Science, Bangalore 12.
8. Shri B. B. Sardeshpande, Chairman, All India Food Preserver's Association Kamani Chambers, Nicol Road, (Kumta St), Ballard Estate, Bombay 1.
9. Shri N. Srinivasan, Industrial Adviser (Chemicals), Ministry of Commerce and Industry, Udyog Bhavan, New Delhi.
10. Dr S. Bhagavantham, Director, Indian Institute of Science, Bangalore.

11. Director-General, Scientific and Industrial Research or his Representative.
12. Dr D. S. Kothari, University Grants Commission, New Delhi.
13. Director of the Institute (CFTRI) .
14. Dr A. N. Bose, Chief Research Officer, Central Fisheries Technologica Research Station, Chittoor Road, P.B. No. 39, Ernakulam 1.
15. Dr D. N. Srivastava, Director of Fruit Utilization, U.P., Ranikhet.
16. Dr A. S. Srivastava, Entomologist to the Govt. of U.P., Kanpur.

**(C) MEMBERS OF THE BUILDING AND EQUIPMENT
SUB-COMMITTEE**

1. Dr S. Bhagavantham, Director, Indian Institute of Science, Bangalore.
2. Superintending Engineer to the Government of Mysore.
3. Director of the Institute.

(D) MEMBERS OF THE FINANCE SUB-COMMITTEE

1. Financial Adviser to the Council (or his Representative who may attend the meeting of the Executive Council).
2. Shri K. K. Birla, 8, India Exchange Place, Calcutta.
3. Dr S. Bhagavantham, Director, Indian Institute of Science, Bangalore.
4. Director of the Institute.
5. Director-General, Scientific and Industrial Research or his Representative.

APPENDIX VII

STAFF

Dr V. Subrahmanyam	<i>Director</i>
Dr A. Sreenivasan	<i>Deputy Director</i>

Storage and Preservation

Dr H. C. Srivastava	<i>Sr. Scientific Officer (I)</i>
Sri V. B. Dalal	<i>Jr. Scientific Officer</i>
Sri H. Subrahmanyam	<i>Jr. Scientific Officer</i>
Dr James Rodrigues	<i>Pool Officer</i>
Sri P. Narasimhan	<i>Sr. Scientific Assistant</i>
Sri N. V. Narayana Murthy	<i>Sr. Scientific Assistant</i>
Miss Zakia Banu	<i>Research Fellow</i>
Miss Habeebunisa	<i>Research Fellow</i>

Infestation Control and Pesticides

Sri S. K. Majumder	<i>Sr. Scientific Officer (I)</i>
Sri M. Muthu	<i>Jr. Scientific Officer</i>
Dr K. Krishnamurthy	<i>Jr. Scientific Officer</i>
Smt. M. K. Krishnakumari	<i>Jr. Scientific Assistant</i>
Sri K. S. Narasimhan	<i>Jr. Scientific Assistant</i>
Smt. S. Godavari Bai	<i>Jr. Scientific Assistant</i>
Sri H. R. Gundu Rao	<i>Jr. Research Fellow</i>
Smt. Athia Banu	<i>Jr. Research Fellow</i>
Sri J. S. Venugopal	<i>Jr. Research Fellow</i>

Biochemistry and Nutrition

Dr M. Srinivasan	<i>Assistant Director</i>
Dr H. S. R. Desikachar	<i>Sr. Scientific Officer (II)</i>
Sri M. V. L. Rao	<i>Sr. Scientific Officer (II)</i>
Dr M. G. Kokatnur	<i>Pool Officer</i>
Sri M. N. Satyanarayana	<i>Jr. Scientific Officer</i>
Dr K. R. Bhattacharya	<i>Jr. Scientific Officer</i>
Dr R. Radhakrishnamurthy	<i>Jr. Scientific Officer</i>
Major O. P. Kapur	<i>Jr. Scientific Officer</i>
Sri J. Meena Rao	<i>Sr. Scientific Assistant</i>
Sri N. Chandrasekhara	<i>Sr. Scientific Assistant</i>
Sri C. Bhuvaneshwaran	<i>Sr. Scientific Assistant</i>
Dr P. P. Kurien	<i>Sr. Scientific Assistant</i>
Sri P. N. Achuthamurthy	<i>Jr. Scientific Assistant</i>
Sri P. V. Subba Rao	<i>Jr. Scientific Assistant</i>
Sri S. N. Raghavendar Rao	<i>Jr. Scientific Assistant</i>

Sri R. D. Thackare	<i>Asst. Research Officer</i>	ICMR
Miss M. B. Rao	<i>Research Assistant</i>	
Dr (Miss) Prema Faterpaker	<i>Asst. Research Officer</i>	
Miss N. S. Girija	<i>Research Assistant</i>	
Sri M. M. Bhargava	<i>Research Assistant</i>	(DAE)
Sri A. D. Deodhar	<i>Research Fellow (WWF)</i>	
Sri D. S. Pradhan	<i>Sr. Scientific Assistant</i>	
Sri Netrawali	<i>Jr. Scientific Assistant</i>	

Dietetics

Dr M. Swaminathan	<i>Assistant Director</i>
Dr R. Rajagopalan	<i>Sr. Scientific Officer (II)</i>
Sri M. R. Chandrasekhara	<i>Sr. Scientific Officer (II)</i>
Dr M. Narayana Rao	<i>Sr. Scientific Officer (II)</i>
Dr R. K. Bhagavan	<i>Junior Scientific Officer</i>
Dr K. S. Ramachandran	<i>Pool Officer</i>
Dr D. Rajagopala Rao	<i>Pool Officer</i>
Dr T. R. Doraiswamy	<i>Sr. Scientific Assistant</i>
Miss Kantha Joseph	<i>Sr. Scientific Assistant</i>
Sri S. V. Chandiramani	<i>Jr. Scientific Assistant</i>
Sri S. R. Shurpalekar	<i>Jr. Scientific Assistant</i>
Miss Mayna D. Panemangalore	<i>Jr. Scientific Assistant</i>
Miss Soma Korula	<i>Research Fellow (Unichem)</i>
Sri P. K. Tasker	<i>Research Fellow (WWF)</i>
Sri H. N. Parthasarathy	<i>Research Fellow</i>

Food Processing

Dr D. S. Bhatia	<i>Assistant Director</i>
Sri C. P. Natarajan	<i>Sr. Scientific Officer (I)</i>
Sri G. S. Bains	<i>Sr. Scientific Officer (II)</i>
Sri N. Subramanian	<i>Sr. Scientific Officer (II)</i>
Sri B. S. Bhatia	<i>Sr. Scientific Officer (II)</i>
Dr K. M. Narayanan	<i>Pool Officer</i>
Sri Y. S. Lewis	<i>Jr. Scientific Officer</i>
Sri S. Kuppaswamy	<i>Jr. Scientific Officer</i>
Sri J. R. Iyengar	<i>Jr. Scientific Officer</i>
Sri M. Kantharaj Urs	<i>Jr. Scientific Officer</i>
Dr K. S. Srinivasan	<i>Jr. Scientific Officer</i>
Sri N. Gopalakrishna Rao	<i>Sr. Scientific Assistant</i>
Dr S. Venkata Rao	<i>Sr. Scientific Assistant</i>
Sri G. Rama Rao	<i>Sr. Scientific Assistant</i>
Sri S. Neelakantan	<i>Jr. Scientific Assistant</i>
Sri G. Chandrasekhar	<i>Jr. Scientific Assistant</i>
Sri S. Venkataraman	<i>Jr. Scientific Assistant</i>
Sri G. Ramanathan	<i>Jr. Scientific Assistant</i>

Sri K. Anantharaman	<i>Jr. Scientific Assistant</i>
Sri K. K. Gopalan	<i>Jr. Scientific Assistant (TRS)</i>
Sri A. Balachandran	<i>Jr. Scientific Assistant (CRS)</i>
Sri T. Philip	<i>Jr. Scientific Assistant (CRS)</i>
Sri A. S. Shankarnarayana	<i>Jr. Scientific Assistant (TRS)</i>

Fruit Technology

Dr G. S. Siddappa	<i>Assistant Director</i>	
Dr J. S. Pruthi	<i>Sr. Scientific Officer (I)</i>	
Sri G. L. Tandon	<i>Sr. Scientific Officer (II)</i>	
Dr L. V. L. Sastry	<i>Sr. Scientific Officer (II)</i>	
Sri G. V. Krishnamurthy	<i>Sr. Scientific Assistant</i>	
Sri Lakshminarayana Setty	<i>Sr. Scientific Assistant</i>	
Sri M. V. Sastry	<i>Sr. Technical Assistant</i>	
Sri B. A. Satyanarayana Rao	<i>Jr. Scientific Assistant</i>	
Sri A. M. Nanjundaswamy	<i>Jr. Scientific Assistant</i>	
Sri K. K. Mookerji	<i>Jr. Scientific Assistant</i>	
Mrs M. Nagarathnamma	<i>Jr. Scientific Assistant</i>	} (F.P.O)
Sri G. R. Rangaiah Naidu	<i>Jr. Scientific Assistant</i>	
Mrs N. V. Subhadra	<i>Jr. Scientific Assistant</i>	
Sri K. Gopinathan Nair	<i>Jr. Scientific Assistant</i>	

Arecanut Technology

Sri V. S. Govindarajan	<i>Arecanut Technologist</i>
Sri A. G. Mathew	<i>Sr. Scientific Assistant</i>
Sri S. D. Venkataramu	<i>Jr. Scientific Assistant</i>
Sri S. A. Jaleel	<i>Jr. Scientific Assistant</i>
Sri E. Sankaran Namboodiri	<i>Jr. Scientific Assistant</i>

Meat and Fish Technology

Dr N. L. Lahiri	<i>Assistant Director</i>
Dr M. N. Moorjani	<i>Sr. Scientific Officer (II)</i>
Dr D. P. Sen	<i>Sr. Scientific Officer (II)</i>
Dr M. A. Krishnaswamy	<i>Jr. Scientific Officer</i>
Dr B. R. Baliga	<i>Jr. Scientific Officer</i>
Sri K. Visweswariah	<i>Sr. Scientific Assistant</i>
Sri S. B. Kadkol	<i>Sr. Scientific Assistant</i>
Sri R. Balakrishnan Nair	<i>Sr. Scientific Assistant</i>
Sri N. V. Sripathy	<i>Jr. Scientific Assistant</i>
Sri N. P. Dani	<i>Jr. Scientific Assistant</i>

Microbiology and Sanitation

Sri D. S. Johar	<i>Sr. Scientific Officer (I)</i>
Dr T. N. Ramachandra Rao	<i>Sr. Scientific Officer (II)</i>
Dr V. Sreenivasamurthy	<i>Jr. Scientific Officer</i>

Dr K. Ramamurthi	<i>Pool Officer</i>
Sri M. S. Subba Rao	<i>Jr. Scientific Officer</i>
Sri K. R. Sreekantaiah	<i>Sr. Scientific Assistant</i>
Sri C. T. Dwarakanath	<i>Sr. Scientific Assistant</i>
Sri Patric Tauro	<i>Sr. Scientific Assistant</i>
Miss T. C. Soumithri	<i>Jr. Scientific Assistant</i>
Sri K. Venkataramu	<i>Jr. Research Fellow</i>

Food Engineering

Sri B. H. Krishna	<i>Assistant Director</i>
Sri S. K. Lakshminarayana	<i>Sr. Scientific Officer (I)</i>
Dr S. S. Kalbag	<i>Sr. Scientific Officer (I)</i>
Sri P. K. Ramanathan	<i>Sr. Scientific Officer (II)</i>
Sri G. H. Byra Reddy	<i>Civil Engineer</i>
Sri M. N. Vasudeva Rao	<i>Sr. Scientific Assistant</i>
Sri J. I. De'Mello	<i>Sr. Scientific Assistant</i>
Sri B. S. Ramachandra	<i>Sr. Scientific Assistant</i>
Sri K. E. Eapen	<i>Sr. Scientific Assistant</i>
Sri R. N. Lingaiah	<i>Sr. Scientific Assistant</i>
Sri K. G. Ramaswamy	<i>Jr. Scientific Assistant</i>
Sri L. S. Subba Rao	<i>Jr. Scientific Assistant</i>
Sri M. Venkateswar Rao	<i>Jr. Scientific Assistant</i>
Sri V. B. Shanbog	<i>Jr. Scientific Assistant</i>
Sri M. B. Subba Rao	<i>Jr. Scientific Assistant</i>
Sri B. K. Ananda Rao	<i>Sr. Refrigeration Mechanic</i>
Sri A. Devaraj	<i>Electrical Supervisor</i>
Sri M. S. Joseph	<i>Workshop Supervisor</i>

Packaging and Containers

(Major) N. V. R. Iyengar	<i>Sr. Scientific Officer (II)</i>
Dr H. B. N. Murthy	<i>Jr. Scientific Officer</i>
Sri P. V. Raju	<i>Jr. Scientific Officer</i>
Sri B. Anandaswamy	<i>Sr. Scientific Assistant</i>
Sri V. R. Sreenathan	<i>Sr. Scientific Assistant</i>
Sri C. S. Viraktamath	<i>Sr. Scientific Assistant</i>
Sri A. R. Vijayendra Rao	<i>Jr. Scientific Assistant</i>
Sri K. R. Subba Rao	<i>Research Fellow (Union Carbide)</i>

Regional Research Stations

Sri H. C. Bhatnagar	<i>Assistant Director</i>
Sri N. K. Saha	<i>Sr. Scientific Officer (II)</i>
Sri S. Ranganna	<i>Sr. Scientific Officer (II)</i>
Sri G. R. Shah	<i>Jr. Scientific Officer</i>
Sri O. P. Beerh	<i>Jr. Scientific Officer</i>
Sri J. V. Prabhakar	<i>Jr. Scientific Assistant</i>

Mrs Satyavati Krishnankutty	<i>Jr. Scientific Assistant</i>
Sri G. G. Bandhopadhyay	<i>Jr. Scientific Assistant</i>
Sri P. C. Agarwal	<i>Jr. Scientific Assistant</i>
Sri V. R. Rane	<i>Jr. Scientific Assistant</i>
Sri B. Venkata Reddy	<i>Jr. Scientific Assistant</i>
Sri M. K. Sreenath	<i>Jr. Scientific Assistant</i>

Information, Statistics and Extension Services

Sri A. Rahman	<i>Assistant Director</i>
Sri R. C. Bhutiani	<i>Sr. Scientific Officer (I)</i>
Sri A. N. Sankaran	<i>Sr. Scientific Officer (II)</i>
Sri K. M. Dastur	<i>Sr. Scientific Officer (II)</i>
Sri V. Balu	<i>Sr. Scientific Officer (II)</i>
Sri B. V. Subbarayappa	<i>Jr. Scientific Officer</i>
Smt. Sarojani Peravali	<i>Jr. Scientific Officer</i>
Dr J. V. Shankar	<i>Jr. Scientific Officer</i>
Sri K. V. Achyutha Rao	<i>Sr. Scientific Assistant</i>
Sri A. V. Venkatesam	<i>Sr. Scientific Assistant</i>
Smt. K. Indiramma	<i>Sr. Scientific Assistant</i>
Sri P. S. Balakrishna	<i>Jr. Scientific Assistant</i>
Sri P. Govindan Kutty Menon	<i>Jr. Scientific Assistant</i>
Sri N. S. Subrahmanyam	<i>Jr. Scientific Assistant</i>
Sri D. Dasappa	<i>Jr. Scientific Assistant</i>
Sri C. V. S. Shailaj	<i>Jr. Tech. Assistant (Hindi)</i>
Sri S. V. Sangameswaran	<i>Librarian</i>

Technical

Dr K. V. Srinath	<i>Senior Scientific Officer (I)</i>
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Agri-Horticulturist

Sri P. C. Ghosh	<i>Sr. Scientific Assistant</i>
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ADMINISTRATIVE STAFF

Establishment and General

Sri Naseeruddin Ahmed	<i>Administrative Officer</i>
Sri E. N. Roy	<i>Section Officer</i>
Sri A. Subramanian	<i>Office Assistant</i>
Sri C. H. B. Nair	<i>Office Assistant</i>

Personal Assistants

Sri K. Ragothama Rao	<i>P.A. to Director</i>
Sri S. Satyanarayana	<i>P.A. to Deputy Director</i>

Works and Purchase

Sri K. M. Cherian	<i>Section Officer</i>
Sri K. B. Rama Rao	<i>Sr. Scientific Assistant</i>
Sri S. S. Raju	<i>Office Assistant</i>

Accounts

Sri M. V. Gopal Rau	<i>Accounts Officer</i>
Sri V. Sitaraman	<i>Sr. Accountant</i>
Sri O. M. Parthasarathy	<i>Jr. Accountant</i>

Watch and Ward

Sri B. S. Cheluvvarajan	<i>Laboratory Supervisor</i>
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Stores

Sri C. N. Bhima Rao	<i>Stores Officer</i>
Sri M. R. Subbanna	<i>Stores Supervisor</i>

Receipt and Issue

Sri B. Ramanna	<i>Senior Stenographer</i>
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